Commodity
Costs and Returns
Estimation
Handbook

A Report of the AAEA Task Force on Commodity Costs and Returns

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Ames, Iowa

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PREFACE

This handbook's purpose is to gather in one place information on estimating costs of and returns to agricultural enterprises. Some of the earliest formal work in agricultural economics related to the analysis and interpretation of cost data (H. C. Taylor). A major task of many individuals over the years has been the preparation and distribution of detailed cost of production estimates and projections. Undergraduate students in farrn management classes have spent many hours learning how to prepare a projected corn or rice budget. In many states the extension service routinely prepares representative cost of production projections for use by area producers. And in many areas farm record associations provide annual cost of production summaries based on data collected from members. The United States Department of Agriculture (USDA) has been involved in the estimation of costs and returns (CARs) to agricultural enterprises for many years, the latest effort under the auspices of the Agricultural Resource Management Study (ARMS). This monograph was prepared by a Task Force organized by the American Agricultural Economics Association's Economic Statistics and Information Resources Committee. The mission given to the Task Force by the committee *was "to recommend standardized practices for generating costs and returns estimates for agricultural commodities after a careful examination of the relevant economic theory and the merits of alternative methods."* The Task Force first met in February 1992. Based on discussions at that meeting, the Task Force was organized into three committees and twelve subcommittees. The drafts of Chapters 3-13 were prepared by these subcommittees. Chapters l-2 and 14-15 were prepared by the steering committee. At later meetings of the Task Force, issues that spanned more than one committee were analyzed and debated. Additional drafts were prepared and distributed to the members of the Task Force. All members of the Task Force had the opportunity to comment on each chapter. The steering committee prepared the penultimate draft based on comments on earlier drafts and consultation with committee chairs concerning inconsistencies between various chapters in the handbook. This draft was distributed to all Task Force members in the Fall of 1996 and was returned in early 1997. 'The final copy before you was prepared by the steering committee and is based on this last set of comments and consultation with committee members.

Thanks are due to many individuals who helped in the preparation of this report. The names of all 68 members of the Task Force are listed in an appendix to the handbook. Special thanks is due to the committee chairs, Ken Paxton of Louisiana State University, Cole Gustafson of North Dakota State University, and Odell Walker of Oklahoma State University. Subcommittee chairs were Jim Wade of the University of Arizona and now of the University of Maryland, Stan Spurlock of Mississippi State University, Darrel Kletke of Oklahoma State University, Glenn Helmers of the University of Nebraska, Lindon Robison of Michigan State University, Wallace Huffman of Iowa State University, Tim Cross of Oregon State and now of the University of Tennessee, Carol House of the National Agricultural Statistics Service, George Casler of Cornell University, Steve Harsh of Michigan State University, and Brian Davey of Ag Canada. Special thanks goes to Jim Johnson and Mary Aheam of ERS who had a big part in the appointment of this Task Force. A number of individuals not on the Task Force were gracious enough to read drafts of chapters. These include Bud Stanton of Cornell, Bruce Bjomson of the University of Missouri, Rob Innes of the University of Arizona, Scott Irwin of Ohio State University, Bruce Gardner of the University of Maryland, and Greg Perry of Oregon State University. The technical editor was Linda Chimenti of Ames, Iowa. Joe Balagtas and Ke Fei Li of Iowa State University were also very helpful in proofing various drafts of the manuscript for readability and computational accuracy. Marilyn Clement of the University of Minnesota was responsible for collecting the initial drafts and preparing a readable document for distribution and editing. Donna Otto of Iowa State provided her standard superb efforts in typing, proofing, and assembling the later versions of the manuscript.

Vernon Eidman, University of Minnesota
Arne Hallam, Iowa State University
Mitch Morehart, USDA, ERS
Karen Klonsky, University of California, Davis

CHAPTER 1

INTRODUCTION

GENESIS AND OVERVIEW OF REPORT

Production agriculture occupies an important role in the U.S. economy, both in terms of the domestic supply of food and fiber and its significant contribution to world trade in agricultural commodities. Agriculture remains a unique industry because of the diversity of farm production coupled with the relatively large number of participants. The historic variability of input and product prices for agriculture, due to weather and other unforeseeable factors, has helped to stimulate producer, consumer, and political awareness of the costs of producing food and fiber. Estimates of commodity costs and returns (CARs) have become one of the basic statistics used to characterize performance in agriculture, yet there seems to be little consensus about the exact components of CARs, or the appropriate procedures to estimate them.

There are many approaches used to arrive at CAR (cost and return) estimates. Differences between approaches stem from the varying purposes for which the information is to be used and the amount and type of data available for determining costs of production. The many purposes for which CAR estimates are developed broadly include farm-level decision making, policy and government program analysis, performance analysis, the study of resource allocation issues, and the archiving of CAR data in a convenient and understandable format. Farm-level decision analysis examines options for a given farm in the coming year, and for longer-range periods using projected information. Policy analysis often uses historical cost information for a group of farms producing the same commodity, or projected CARs, to analyze the likely impacts of proposed policy change. The study of efficiency of resource allocation usually involves details on the components of CARs for a composite of farms. Economic or financial performance of a particular enterprise can involve both historical and projected cost information for a single farm and/or a group of farms. To address these various information requirements, CAR estimates are prepared to provide measures of the costs of producing a unit of a commodity for a specific farm, for an average or representative farm in a region, or for an average or representative farm for a nation as a whole.

Recognizing the variety of approaches used and the inherent problems created for interpretation and use of CAR estimates, a national conference was held in Kansas City during February 1991. The conference brought together analysts from universities and government, statisticians, political scientists, extension workers, and farmers to examine how different purposes for measurement of enterprise CARs may lead to alternative estimation methods and to explore preferred approaches. One outcome of this conference was the establishment of a Task Force by the American Agricultural Economics Association's Economic Statistics and Information Resources Committee. The mission given to the Task Force by the committee was *"to recommend standardized practices for generating costs and returns estimates for agricultural commodities after a careful examination of the relevant economic theory and the merits of alternative methods."*

This report discusses alternative methods to estimate enterprise CARs for agricultural production, and identifies both conceptual and practical issues faced when evaluating alternative estimation methods. The report points out the merits and flaws of these methods and suggests guidelines to apply in preparing estimates for use in planning individual farm businesses, financial consulting work, teaching, extension, research, and policy analysis. This effort addresses the growing concern among professionals in agricultural economics about how CAR estimates are used by noneconomists as well as by economists and the responsibility of those presenting CAR estimates to do so in a way that the estimates will be used correctly, to the advantage of society. In publishing this information the Task Force does not intend to imply that recommendations provided should be viewed as a rigid, inflexible set of rules, but rather as a set of guiding principles.

The National Task Force on Commodity Costs and Returns Measurement Methods consists of professionals from various agricultural institutions. The Task Force operates under a committee structure which is coordinated through a steering committee. The Task Force has provided an organized forum for the exchange of ideas among those performing costs of production analysis in land grant universities, the United States Department of Agriculture (USDA), and other agricultural research institutions. Establishing uniformity in the terms, methods, and presentation of CAR estimates developed for similar purposes will help to broaden the use and understanding of the financial conditions of various enterprises. Also, the Task Force recognizes that as technology and other conditions change, the approach to CAR measurement may also change.

The goal of the Task Force is to develop a report that

1. defines relevant terms;
2. defines what is to be measured;
3. explains the relevant theoretical and accounting issues;
4. discusses appropriate ways to apply theoretical principles to empirical data;
5. contrasts alternative measurement methods and provides recommendations on preferred methods;
6. discusses the appropriate data sources;
7. recommends a format for the output, including specification of the assumptions and data sources; and
8. recommends methods for verification, updating, and sharing data bases.

ORGANIZATION OF THE HANDBOOK

This handbook is organized around the major issues in preparing CAR estimates. Each chapter outlines a set of issues, discusses alternative methods for obtaining estimates, presents examples, and suggests a preferred approach for CAR estimation. A brief outline of each chapter and highlights follows.

Chapter 2 - Conceptual Issues in Cost and Return Estimates

Chapter 2 lays the groundwork for the remainder of the report by defining many terms and introducing concepts that will be developed in more detail later. The chapter distinguishes historical and projected estimates and individual farm versus composite estimates. The Task Force recommends that the end of the production period be the reference point in time at which to value all CAR estimates. An important distinction is drawn between expendable inputs which are used up during the production period and capital inputs which provide service over several production periods. The Task Force strongly endorses the idea of using market transactions to value CAR flows. When market transactions are not available, the opportunity cost of the relevant factor or product should be used to estimate CARs. Opportunity costs should, in general, reflect implicit market values. For example, produced expendable inputs should be valued at the cost of purchasing the input from off-farm. Similarly, capital services provided by the owner of a given enterprise should be valued at the cost of obtaining these services from an alternative source in an arm's length market transaction.

Chapter 2 discusses the time preferences, discounting and the rate of interest. The Task Force recommends that all transactions be valued at the same point in time using standard discounting formulas. Given the fact that most price data is reported in nominal form, the Task Force recommends that all CAR estimates be reported in nominal terms as of the end of the production period. To ensure that real and nominal values are equivalent at the base time point, the Task Force recommends that the base point in time for the computation of all real values be the end of the current production period or the end of the current year, whichever is chosen as the base time point for CAR estimation. Nominal CAR flows for periods other than the current one should be adjusted to the end of the current period using the appropriate interest rate. Real CAR flows for periods other than the current one should also be adjusted to the end of the current period using the appropriate interest rate. The Task Force recommends that analysis outside the current production period generally be done in real terms so that no assumptions (other than zero inflation since the analysis is real) about inflation are made for periods other than the current one. The Task Force recommends that the exact Fisher formula

$$\begin{aligned}(1+i) &= (1+\pi)(1+r) \\ \Rightarrow i &= r+\pi+r\pi\end{aligned} \tag{1.1}$$

be used to model the relationship between the nominal interest rate (i), the real interest rate (r), and the rate of inflation (π). The Task Force recommends that interest charges and adjustments within a period be made using the exact monthly compounding formulas. Specifically the interest charge (ic) on an expenditure (R) n months from the end of the production period is given by

$$ic = R(1+i)^{\frac{n}{12}} - R. \tag{1.2}$$

The Task Force recommends that the bottom-up approach be used to estimate a nominal risky rate for agriculture. The Task Force suggests a real rate of interest based on government securities such as treasury bills and notes, a risk adjustment based on the relative riskiness of agriculture compared to the rest of the economy, and an inflation adjustment based on the chained price index for the consumption component of GDP. Specific formulas, data, and examples are presented in the chapter.

The Task Force recommends that the capital recovery approach based on annuities representing the costs of owning capital assets be used to value the services of owned capital when market transactions are not readily available. The capital recovery approach approximates capital service cost (CSC) by mimicking the various costs of providing the services of a capital asset to a user for one period. Specifically, this report defines capital service cost for one period as

$$
\begin{aligned}
\textit{Capital service cost (CSC)} &= \textit{Opportunity cost of holding the asset} \\
&+ \textit{service capacity reduction cost} \\
&+ \textit{change in the price of the capital asset's service capacity} \\
&+ \textit{service enhancement cost} \\
&+ \textit{maintenance cost} \\
&+ \textit{other time costs}.
\end{aligned}
$$

The first item is typically estimated as iV_0 where i is the nominal rate of interest and V_0 is the value of the asset at the beginning of the period. Service capacity reduction cost refers to the fact that the remaining use value of a capital asset usually declines with use. The last three items are often included as separate costs, and the first three used as an approximation to CSC. Given the approximation, the second two items are equivalent to the change in value of the asset over a period. The report defines this change (V_0 - V_1) as economic depreciation where V_1 is the value of the asset at the end of the period. This then gives the shorthand formula for CSC

$$
\begin{aligned}
\textit{Capital service cost (CSC)} &\approx \textit{Opportunity cost} + \textit{service reduction cost} + \textit{change in price} \\
&= \textit{Opportunity cost} + \textit{Economic depreciation (ED)} \\
&= iV_0 + (V_0 - V_1).
\end{aligned}
$$

The real annuity approximating capital service cost is given by

$$
a^r = \frac{\left(V_0 - \dfrac{V_n^r}{(1+r)^n} \right)}{\left(\dfrac{1 - \dfrac{1}{(1+r)^n}}{r} \right)}.
$$

where V_n^r is the real valued of the asset at the end of n years of life. The Task Force suggests that this real annuity be adjusted to nominal terms at the end of the production period using the current inflation rate.

The Task Force recommends that the microeconomic concepts of fixed and variable costs not be used in preparing and reporting CAR estimates. Instead, the Task Force recommends that costs should be categorized as to whether they are associated with expendable factors or the services of capital assets. For the purpose of preparing CAR estimates for specific enterprises, the Task Force recommends that all the costs of expendables be allocated to the generic group OPERATING COSTS and that all other costs be allocated to the group ALLOCATED OVERHEAD.

Chapter 3 - Revenues and Government Programs Participation

Chapter 3 discusses issues related to calculating revenues from the sale of products, government program payments, and miscellaneous sources. The examples on government revenue refer to the 1991-1996 period, since that is when the bulk of this report was prepared. Modifications for changes in programs can be made as they occur. Estimated revenue to an enterprise should include the value of primary products produced by type and grade, the value of any by-products produced, government payments, and other receipts associated with the enterprise such as patronage dividends, crop insurance receipts, and market pool returns. The Task Force recommends that commodity yields and prices be estimated at the end of the production period, or the point in the production-marketing process at which the commodity leaves the ownership of the grower, whichever is more appropriate for the purpose of the analysis. Costs and revenues should be compared in a common time frame to be valid. ***The end of the production period is the recommended time period to compare all costs and revenues.*** However, many commodities are harvested over several months and have no single harvest month. All revenues and costs should be compounded/discounted to a common point in time as discussed in Chapter 2. The recommendation to adjust all revenues to a given harvest month or end of the year does *not* imply that a harvest month or end-of-year price should always be used. The price at which the product was sold (or is expected to be sold), adjusted to a common time point, is the appropriate price. The Task Force also recommends that CAR estimates for crops be done on a planted-acre basis. Keeping revenue and cost calculations on a planted-acre basis incorporates acreage not in production, but needed for that particular production system. This is particularly important in situations where government mandates set-aside acres or the cropping system involves fallow periods. Cost and return estimates should be carefully prepared to ensure that inputs, outputs, costs, returns, and management levels are mutually consistent. For example, if a product is routinely stored for some period on the farm before sale, costs and losses due to storage should be included in the analysis.

Chapters 3 and 4 discuss the pricing of products produced by one enterprise and used by another enterprise. In the case of such factors, the Task Force recommends using the cost of purchasing the factor from off-farm as the cost of the factor to the utilizing enterprise because this reflects the opportunity cost of the factor to the utilizing enterprise. And similarly, the Task Force recommends using the market price of selling a product from off-farm as the revenue to the producing enterprise because this reflects the opportunity cost of the factor to the producing enterprise. In situations where transactions costs are large and buying and selling prices for products are not the same, the net position of the operation as a net buyer or seller of the commodity in question must be considered. If the farm is a net seller of the product (produces some for on-farm use and some for off-farm sale), the Task Force recommends the product be valued to the producing enterprise at its net selling price (market price minus transactions costs) and to the utilizing enterprise at its net buying price (market price plus transactions costs). This applies the appropriate opportunity cost to each enterprise. The difference in cost per unit is a return to the marketing enterprise or vertical integration in the business.

Chapter 3 suggests ways to handle revenues from forward, futures, and options transactions, particularly in the case of historical estimates. The chapter provides an extensive discussion of data sources that can be used to estimate commodity prices. The chapter also suggests appropriate ways to adjust data to fit particular enterprise situations. A detailed discussion of how to handle participation in government programs is provided along with several example calculations. The chapter concludes with a discussion of miscellaneous revenues and how they are included in CAR estimation.

Chapter 4 - Purchased and Farm-Raised Expendable Inputs

Chapter 4 discusses how to estimate the costs of expendable inputs for an enterprise, whether purchased or produced as part of a larger operation. The cost of an input for a given enterprise is the price of the input (if it was purchased from an off-farm supplier) or the opportunity cost of the input (if it was produced on the farm) multiplied by the quantity used per unit of the enterprise. In cases where such data is not available, the chapter suggests alternative ways to obtain estimates. The Task Force suggests that fertilizers with significant carry-over effects should be handled as capital inputs rather than as expendables. The Task Force suggests that manure be treated as a by-product with nutrient value with a positive cost of handling that may exceed its nutrient value. The Task Force recommends that chemicals be identified by chemical name as well as a trade name. To simplify pricing, cost reporting, and uses of the information contained in the CAR estimate to address environmental and rotational questions, a detailed listing of brand names, pounds of active ingredient, and chemical formulation (such as wettable powder, granular, or aqueous suspension) and concentration is preferred.

Chapter 4 discusses alternative methods for pricing farm raised feeds for livestock. As mentioned in summarizing Chapter 3, the preferred method is to use the off-farm opportunity cost whenever possible. The chapter also discusses how to estimate the cost of feed additives and concludes with a section on grazing fees.

Chapter 5 - Machinery, Equipment, and Buildings: Operating Costs

Procedures to use in calculating the costs of using machinery, equipment, buildings are presented in Chapters 5 and 6. Chapter 5 discusses the operating costs associated with these capital assets while Chapter 6 addresses the ownership costs of these assets. Expenditures for maintenance and other time costs for capital assets often involve the use of expendable inputs such as lubricants, parts, hired services, or operator labor, thus they are often estimated in conjunction with other operating costs such as seed, fertilizer, and supplies. Chapter 5 addresses alternative ways to estimate these machinery operating costs and provides extensive discussion of the use of engineering equations to estimate these costs for crop enterprises. The American Society of Agricultural Engineers (ASAE) publishes procedures for estimating the costs to own and operate farm machinery and these are the most common way to estimate the costs of repairs, fuel, and lubrication. The chapter provides extensive examples of how to estimate these costs accounting for inflation, different hours of use per month, and changes in useful life. Simple constant costs per hour of use and costs adjusted for the time pattern of repairs are analyzed. The appropriate way to handle operating costs on repairs is also discussed.

Chapter 5 has a detailed section on the cost of operating and using irrigation equipment. The costs of the rights to use irrigation water are discussed in Chapter 9, while the appropriate way to value an existing well or pumping machinery is discussed in Chapter 6.

Chapter 5 follows up on the discussion from Chapter 2 with a detailed discussion on operating interest. Various alternatives are presented. The Task Force recommends the exact method which says that the nominal interest charge for the j^{th} expense C_j (incurred n_j months from the terminal point of the estimation procedure) is calculated as

$$(\mathit{interest\ charge})_j = C_j(1+i)^{\frac{n_j}{12}} - C_j$$

where i is the annual nominal interest rate. The total of all interest charges can be computed as

$$\mathit{interest\ charge} = \sum_{j=1}^{m}\left(C_j(1+i)^{\frac{n_j}{12}} - C_j\right)$$

where m is the number of expenses on which interest is charged.

Chapter 5 also discusses problems involved in estimating the fair market value of custom operations whether they occur as an expense or a revenue. The Task Force suggests that in situations where custom operations are common and the market well tested, the custom rate may be a better source of machinery costs than can be obtained using the engineering equations and the capital recovery procedures discussed in Chapter 6.

The chapter concludes with a discussion of a variety of commodity specific costs. Topics include drying costs, storage costs, transportation costs, ginning costs, shearing costs, marketing charges, cartons, bags, tags, etc., involuntary checkoffs, marketing order assessments, permits and quotas, and crop insurance.

Chapter 6 - Machinery, Equipment, and Buildings: Ownership Costs

Chapter 6 discusses estimation of the ownership costs of machinery, equipment, and buildings. The chapter depends heavily on Chapter 2 and suggests capital recovery as the preferred method to estimate the ownership costs of capital. The Task Force recommends using the remaining value equations developed by Cross and Perry (1995, 1996) to estimate the salvage value of tractors, combines, and other farm equipment. The chapter discusses the traditional method of computing ownership costs using straight-line depreciation and opportunity interest on a machine midvalue. This procedure is rejected in favor of the real capital service cost formula given by

$$CSC = \frac{\left(V_0 - \frac{V_n}{(1+r)^n}\right)}{\left(\frac{1 - \frac{1}{(1+r)^n}}{r}\right)} = \frac{\left(PP - \frac{SV}{(1+r)^n}\right)}{\left(\frac{1 - \frac{1}{(1+r)^n}}{r}\right)}. \qquad \textbf{(6.7)}$$

where r is the real rate of interest, V_0 and V_n are in real terms, PP is the purchase price of the machine in real terms and SV is the salvage value in real terms. This annuity can then be adjusted to the end of the production period in nominal terms using the current year's inflation rate. The chapter provides a complete example calculation for the case of zero and non-zero inflation. The chapter also discusses other time costs such as property taxes, insurance, and housing. The chapter concludes with a section on joint costs and the determination of an optimal machinery complement. Appendix A to Chapter 6 discusses the estimation of ownership costs when productivity of the asset varies significantly over its useful life.

Chapter 7 - Land

Chapter 7 discusses the costs associated with owning and operating land. The chapter makes a clear distinction between land's agricultural use value and its market value and suggests that the agricultural use value is appropriate for measuring costs of production. The major costs of owning land are the opportunity cost of the land and property taxes. The land may also incur some service reduction and maintenance costs like other capital assets. In areas where cash rent is common, the Task Force recommends the cash rental rate as the appropriate value for the service provided by the land. In some cases share rental rates can also be used. Only in limited situations, should capitalization or net return methods be used to value the service provided by land.

Chapter 8 - Labor and Management: Farm Labor and Related Services

Calculating the quantity and cost of human services (labor and management) is discussed in Chapter 8. Two major categories of farm labor are proposed: (1) hired labor without farm ownership claims, and (2) unpaid farm labor and salaried farm labor having ownership claims. The cost of hired farm labor (type 1 farm labor) is the sum of all the costs the producer pays to obtain the services, including wages, salaries, fringe benefits, and other hired labor associated costs. Several alternative methods for valuing unpaid farm labor and salaried farm labor having ownership claims are evaluated. The preferred implicit compensation for unpaid farm labor is based on the opportunity cost of off-farm work, or the return available in the next best alternative use of this labor time and effort. The particular opportunity cost suggested is the off-farm wage, paying careful attention to point-in-time availability or use and quality dimensions, and local economic conditions. The chapter suggests that this cost of a farm operator's labor in farming can be forecast from a wage equation, given the operator's characteristics and local economic conditions. The chapter also suggests procedures for producing this wage information using hedonic wage equations. The chapter discusses alternative ways of distributing estimated wage data for ease of use. The chapter also discusses the issue of how to estimate the quantity of farm labor used by a given enterprise and the whole farming operation.

Chapter 9 - Joint Costs, General Farm Overhead, and Rights to Produce

Chapter 9 discusses a variety of topics related to the allocation of costs that are incurred by several enterprises. Joint production costs are defined as costs that are incurred on groups of products rather than on individual and separate ones. At least three different situations give rise to joint costs. These include (1) expenses incurred in the production of joint products (defined as technically interdependent commodities arising from a joint technology), (2) expenses for inputs that affect the production of more than one enterprise (independent but organizationally related commodities) even if the production technologies are non-joint, and (3) outlays for production inputs that are either purchased for the farm as a whole or are used for the entire set of production activities undertaken by the farm. The second category is best exemplified by the allocation of capital inputs (and/or their services) or fixed expendable inputs to different enterprises. For example, the total number of tractor hours is divided between crop and livestock operations. The third category is usually referred to as general farm or business overhead and typically includes items for which it is difficult or impossible to determine the impact of the input on either output or cost for a specific enterprise. For example, it is difficult to determine the impact of buying a new set of Allen wrenches on the average corn yield per acre. Each of the three situations may give rise to joint costs that occur either as direct costs or as indirect costs. Direct costs are defined as those costs that can normally be associated with a specific enterprise though not necessarily with individual products generated by the enterprise. Indirect costs are those costs which may apply to several enterprises or production cycles. The Task Force recommends that costs of production for joint technologies be estimated for the technology as a whole allowing for multiple outputs in the enterprise definition. In cases where there is a need to estimate costs for individual outputs such as for corn and soybeans in rotation, the Task Force recommends that costs be allocated to each crop reflecting the amount of input applied for use by that crop and that neither warehouse nor mine inputs. In the case of non-joint technologies, the Task Force recommends that the costs of inputs be allocated based on objective data on individual enterprise use. The Task Force recommends the use of data on land allocations, hours of use, acre-trips, pounds applied, etc., to determine these allocations. If objective data on the allocation of inputs between enterprises is not available, the costs of these inputs should be excluded, should remain unallocated, or in rare instances allocated following the guidelines pertaining to general farm overhead expenses.

The Task Force generally recommends excluding estimates of general overhead expenses from enterprise CAR estimates when those costs cannot be allocated on an objective basis. When allocation is necessary to compute the total costs of production for a specific enterprise, however, the method chosen should be enterprise neutral; i.e., enterprise selection or production decisions made after this allocation should coincide with those made before the allocation. Suggestions of such methods are presented in the chapter. For general farm overhead, the Task Force recommends when an objective method to allocate general farm overhead is not available, the allocation be based on enterprise gross margins.

Chapter 9 also discusses rights to produce which pertain to incidents of ownership of resources used in production, the impact of regulations governing the use of those resources, access to markets for the commodities produced, and access to enhanced prices or other incentives associated with market access. These rights generally involve payment of rent, royalties, increased production costs, or foregone production in exchange for benefits of enhanced production or markets. The chapter lists a variety of such rights including irrigation and grazing and suggest ways to estimate the costs of acquiring and exercising them.

Chapter 10 - Allocating Preproductive Costs for Multiyear Enterprises

Chapter 10 discusses methods to estimate preproductive costs as well as considerations in allocating them to individual enterprises. Many enterprises are of a multiyear nature. A multiyear enterprise is an enterprise with more than one annual production period. The preproductive period for a multiyear crop enterprise begins with the first expense associated with establishing the crop enterprise and ends in the crop year just before the crop yields a substantial percent of its expected mature yield (usually 70-80%). An example of a multiyear enterprise with one preproductive year is alfalfa. A single-year enterprise with a multiyear preproductive period is an enterprise that has harvestable yield in only one year but requires several years to establish and produce. An example would be Christmas trees. Issues of inflation and discounting are important in correctly reflecting preproductive costs and allocating them over the life of the crop or livestock enterprise. Given that current data is most frequently used to prepare preproductive cost estimates, the Task Force recommends that such data be used to estimate costs and returns for each preproductive period as if they occurred for the current time period and that these data then be adjusted to the period of occurrence. Specifically, the Task Force recommends that preproductive costs be computed for each preproductive year using current nominal CAR data. These costs should be adjusted to the end of the respective year using the current nominal interest rate. Following the recommendation from Chapter 2, the Task Force suggests that these costs be adjusted to reflect expenditure at the end of their period of occurrence relative to the current one by using the current nominal interest rate for the current year and the real interest rate for years prior to the current year.

The Task Force recommends that preproductive costs be allocated over the life of an enterprise using the cost recovery (annuity) method outlined in Chapter 2. The annualized real preproductive cost is estimated as

$$A_{CR} = \frac{\left(PPC - \dfrac{SV}{(1+r)^{(N-J)}} \right)}{\left(\dfrac{1 - \dfrac{1}{(1+r)^{(N-J)}}}{r} \right)} \qquad \textbf{(10.6)}$$

where PPC is total preproductive costs adjusted to the beginning of the first productive period, r is the real interest rate, N is the total life of the enterprise, J is the number of preproductive years, and SV is any salvage value of the enterprise in the same dollars as PPC. This can be adjusted to nominal terms at the end of the first productive period using the current inflation rate.

Chapter 10 also discusses the traditional method of allocating costs using straight-line depreciation and interest on a midpoint asset value, the current cost method, the historic cost method and the market value method. The last three methods are more commonly used for livestock enterprises where the enterprise is in some type of long-run equilibrium with acquisition and sales of capital assets such as breeding stock on a regular basis. A detailed example for a dairy operation is presented in connection with the example farm in Chapter 13. The Chapter concludes with a section discussing the comparison of annual and multiyear enterprises and the use of equivalent annual annuities.

Chapter 11 - International Comparisons

All of the considerations discussed in Chapters 1 through 10 are important in preparing CAR estimates for comparisons among countries. In addition, consideration of exchange rates, inflation rates, policy-induced price distortions, differences in technology, and other issues of importance in making such comparisons are discussed and illustrated in Chapter 11. Chapter 11 discusses some common differences in estimates between countries, alternative sources of data, and ways to create estimates that can be easily compared. Special attention is given to issues related to inflation and exchange rates. The chapter includes a detailed example comparing corn production in Honduras and California.

Chapter 12 - Data Sources and Statistical Issues

Chapter 12 analyzes issues related to obtaining the required data for CAR estimation, verification of the data, updating, and sharing the data. The chapter provides a brief primer on survey sampling and the collection of data for CAR estimation. The chapter also reviews a number of studies that have compared estimates prepared in various states and nationally using alternative data sources and methods. The chapter has a short section of reliability issues including sampling variability and sample bias. The chapter also suggests ways to improve data collection in the future. Appendix 12A gives an overview of statistical sampling techniques.

Chapter 13 - Structure and Content of Cost and Return Reports

Cost and return estimates are presented in a wide range of formats. Some of the important considerations in selecting a format and recommendations for the organization of CAR estimates are given in Chapter 13. The Task Force recommends two CAR summaries. The first is a simple, one-page CAR summary with little detail, a limited list of aggregated input items, and an estimate of residual returns over included costs, properly labeled. The second provides data on the units, prices, and quantities, in addition to the total values. Items are more disaggregated but the format is still one readable page. The Task Force suggests that the these summary tables be heavily footnoted with information on how the results in each line of the summary table were obtained. The Task Force also recommends that each CAR estimate include appropriate supporting tables, including details that cannot be provided in the one-page summaries. Chapter 13 presents an extremely detailed example of a Minnesota dairy enterprise. Real and nominal estimates are provided for this multiyear enterprise. A number of alternative approaches are also considered. The footnotes and supporting tables for this example are very complete, giving careful attention to detail so that practitioners can see exactly how to implement Task Force recommendations. The chapter also provides suggestions on data verification, editing, updating, and sharing.

Chapter 14 and Chapter 15 - Examples of Cost and Return Estimates

The final two chapters illustrate many of the concepts discussed in the report. Chapter 14 includes CAR estimates for an upper-Midwest dairy farm growing corn, soybeans and hay. Chapter 15 contains projected estimates for the production of almonds and cotton in California. Like the examples in Chapter 13, the estimates and supporting tables are quite detailed.

SUMMARY

The guiding principles for this handbook are the use of opportunity cost, appropriate discounting of values over time, internal consistency and the use of market values as the basis for all estimates. Numerous individuals have contributed to this handbook. The recommendations presented here are a consensus of the many formal and informal discussions between members of the Task Force. While not everyone agrees completely with everything contained herein, the recommendations here provide a clear guide to the issues and the preferred methods to use. Throughout this report, recommendations of the Task Force are shown in ***bold italics***. Happy reading.

CHAPTER 2

CONCEPTUAL ISSUES IN COST AND RETURN ESTIMATES

Cost and return (CAR) estimates are developed and used for a variety of purposes. In general, the objective is to accumulate or to develop information about costs and returns that can be used in making or analyzing decisions. Such decisions are made by individuals at the firm level or by society through their representatives. The appropriate procedures for calculating these estimates, the sources of data, and the format in which the estimates are presented depend upon both the question being addressed and the intended audience. This chapter discusses the major conceptual issues that influence the components of CARs, methods of calculation, and types of data used. The recommendations of the Task Force are shown in ***bold italics***.

DEFINITION OF AN ENTERPRISE

Commodity CARs in agriculture are commonly summarized by production enterprise. A **production enterprise**, referred to as an **enterprise** in this report, is any coherent portion of the general input-output structure of the farm business that can be separated and analyzed as a distinct entity. Such an entity uses inputs and incurs costs while producing products or services. The entity is usually defined based on a unit of measurement such as an input (sorghum production per acre of land or total pork production per sow), an output (a ton of peas or 100 board feet of lumber), or some fixed set of resources (orange production for a grove). The appropriate unit of measurement is often dependent on the use for which the estimates are intended.

A farm or ranch business can be divided into enterprises in several different ways depending on the products produced, the technology used, or the restrictions on the uses of various inputs. A common delineation of enterprises is along commodity lines (for example, the barley enterprise, the dairy enterprise, or the rice enterprise). In many instances such a neat division is not possible or not desirable. For example, there is not a meaningful way to separate barley grain and barley straw enterprises, or milk production and cull dairy cow enterprises. Similarly, given the rotation effects of growing corn and soybeans in sequence, there may be little economic sense in separating these entities even if it were feasible technically to do so. For some analyses, such as comparing labor use or revenue in crops versus livestock, the enterprises may be defined as broadly as crops and livestock. An enterprise can then consist of one of many entities: a single commodity such as apples or lettuce; double crops such as wheat and soybeans in the same year; different production practices for the same commodity such as no-till versus conventional till barley; multiple crops over several years such as corn and soybeans; a livestock feeding operation such as cattle or sheep; an integrated breeding and finishing operation such as farrow-to-finish swine; a production activity such as slaughter hogs with manure by-products; an add-on activity such as grazing of wheat pasture; a crop with a nurse crop enterprise such as alfalfa hay and oats; or a sideline activity such as custom harvesting. A given farm or ranch may well be divided into enterprises differently for different purposes of analysis. These examples show good cause for allowing for considerable flexibility in defining enterprises.

Chapter 2. Conceptual Issues in Cost and Return Estimates

The Task Force recommends that presentations of CAR estimates clearly indicate the unit of measurement and that they define the set of products, by-products, and/or the services generated by the enterprise.

TYPES OF CAR ESTIMATES AND THEIR USES

Cost and return estimates may be reported at many different levels of aggregation. While more specific definitions are presented in the next section, at the most basic level, a cost is simply the value of resources consumed, frequently given by the price of an input (such as the price of nitrogen fertilizer per ton), whereas a return is the value received (frequently in cash) for an economic good (such as the price of a ton of hay). Costs can be aggregated in many different ways. Examples of different cost aggregations include the cost of all fertilizer used in growing 800 boxes of bell peppers, the cash costs of producing a hundred weight of milk, the costs of rented land to the whole farming operation, the total costs of producing all the corn in Iowa, or the costs of labor in U.S. agriculture. Similarly, returns can be aggregated in different ways. One of the most common ways to aggregate CAR is by enterprise, but estimates can just as easily be made for aggregations other than enterprises. For example, aggregate U.S. net farm income is an estimate of the CAR to all U.S. agriculture during a given period.

Cost and return estimates can also be reported for different periods or points in time. Most commonly, CAR estimates are reported for the previous or the next production period. Estimates for a previous period are called **historical estimates** because they are based on actual costs and returns that were incurred over the period, while estimates for future periods are called **projections** because they are based on forecasted magnitudes. Record summaries prepared by accounting firms and management services are an example of historical estimates. The CAR summaries prepared the Economic Research Service (ERS) are another example of historical estimates. Projections are regularly made at the individual commodity and whole-farm levels (for production and financial planning) and at the sector level (projected farm income).

The diversity of information required for agricultural decision making has spawned the development of a variety of CAR estimation procedures and formats for presentation of results. Arguably, no particular CAR estimate is suitable for all purposes at all times.

The Task Force recommends distinguishing between historical and projected CAR estimates. The Task Force further recommends differentiating estimates prepared for a single farm enterprise from those summarized for a composite of farms.

Definitions of Specific Types of Estimates

Concise definitions of the different types of estimates are shown immediately below. More detailed background to the definitions is given in the subsection that follows.

Historical CAR estimates for production enterprises are a summary of enterprise CARs for some historical period such as the past calendar year, crop year, or production cycle.

Projected CAR estimates for production enterprises are forecasts of enterprise CARs for some future period such as the coming calendar year or crop year and are based on information available at a certain point in time.

An **individual farm** is either a specific farm currently or previously in operation or a representative farm that has a set of resources, production practices, objectives, and enterprises similar to some class of actual farms. An example of a representative farm would be a 350-acre small grain, hay, and dairy farm in Cache County, Utah, patterned after farms in the county.

A **composite of farms** is a simple or weighted average of enterprise CARs for some period for some group of individual or representative farms. An example would be the production costs for all current wheat farms in Kansas.

Background to Definitions

A **historical CAR estimate for an individual farm** is based on the CAR recorded and allocated to the several enterprises on the farm for a previous time period. This type of estimate could be calculated and used by farm operators to make quantitative evaluations of past performance of a specific enterprise in relation to other enterprises on the farm, with projections, or in comparison with other standards. Just as an income statement or balance sheet provides a source of information for whole-farm management, marketing, or financing decisions, the historical CAR estimate for an enterprise allows the producer to evaluate past management decisions involving that particular enterprise. A combination of enterprise CAR estimates can be used to evaluate the relative performance of various enterprises as part of the total operation. Historical CAR estimates for individual farms are often used by policy analysts to evaluate commodity programs, by lenders as guides to help them make decisions regarding loans to producers, and by extension specialists in providing guidance and counseling on specific production problems.

A **historical CAR estimate for a composite of farms** is a simple or weighted average of enterprise CARs for some historical period. A combination of production practices, sizes of operations, land tenure relationships, crop varieties, or livestock breeds may be represented in a single summary of CARs. For heterogeneous enterprises, the relative weights that are applied to aggregate the parts into a summary affect the outcome. The most common aggregation method is to use population weights that are proportional to acreage, sales, or production. A common but less satisfactory alternative is to use equal weights. Composite CAR estimates are prepared by the United States Department of Agriculture (USDA) to represent the entire United States, the major production regions, and selected states. Data from university or private farm record systems are often summarized in a composite format at the state level and for different groups of farms within a state. Common uses of composite historical CAR estimates are evaluation of the effects of government programs, analysis of changes in technology or investment on net returns, and comparison of interregional differences in agricultural production.

A **projected CAR estimate for an individual farm** is a forecast of CARs for a specific size, location, and system of production. In many instances the forecast of components of CARs is based on an evaluation of the farmer's expectations relative to other general information. Projected CAR estimates are used by producers to determine financial requirements, plan for profit-increasing production adjustments, make marketing decisions, and resolve numerous other business management problems. Projected CAR estimates may also be made for representative farms. Such estimates can be used to evaluate alternative production practices and management systems for educational purposes or to provide a starting point for individual producers. The estimates are often used by researchers in evaluating new technologies, the feasibility of new products, or the off-site (environmental) effects of alternative cropping and livestock systems. Projected composite estimates may be useful for projecting regional comparative advantage or evaluating the potential effects of a particular government policy on a group of farms.

Projected CAR estimates are sometimes developed for **composite farms**. These estimates represent an average or weighted average of the CARs a set of farms is expected to experience during some future time period. Projected farm income is an example of this type of estimate.

SCOPE OF CAR ESTIMATES

It is important to prepare both historical and projected enterprise CAR estimates with a clearly defined beginning and ending point in order to make meaningful comparisons across farms, regions, and countries.

> ***The Task Force recommends estimating CAR for the production period when it does not exceed 12 months in length. For enterprises with overlapping production periods (such as breeding livestock) or production periods longer than 12 months, the Task Force still recommends using a 12-month period. In situations when a longer period might be warranted for some purposes (cow-calf operations, sugarbeets, or tree crops), the Task Force recommends that such estimates also be reported on an annualized basis for comparison with other enterprises.***

If other periods are used, as may sometimes be appropriate for a given type of analysis, clear specification of beginning and ending points is important. The production period covered begins with the first resource use (and associated costs incurred) by the enterprise, such as first tillage operation, first purchased input, or preparation of facilities. The period ends at the time of physical transfer of the saleable product(s) from the enterprise and includes all costs required to produce the saleable product(s). Marketing then begins when production ends. In many instances there may not be a clear delineation between the CARs associated with production and those associated with marketing. Certain commodities require some processing to produce saleable commodities (e.g., cotton ginning, or cleaning and grading of fruits and vegetables); with other commodities, part of the production process constitutes considerable value added (e.g., field boxing of lettuce).

The Task Force recommends that although CAR estimates for periods longer than one year may sometimes be appropriate (e.g., cow-calf operations), or a clear distinction between production and marketing activities cannot be made, any deviation from the beginning and ending points recommended above should be clearly noted on the statement of CARs.

Once the production period is defined, a specific point (or points) must be chosen at which to value all CARs. Historical CAR estimates, particularly those generated from accounting systems, typically record the nominal dollars of receipts and expenses when they occur. A similar approach is often used for projected CAR estimates. With inflation, the entries for several different points in time are expressed in dollars that have different purchasing power. Expressing all CARs at one point in time corrects for this problem, making comparisons across enterprises more accurate.

The Task Force recommends that projected CAR estimates establish the end of the production period as the reference point in time at which to value all CARs, and that historical estimates also use this end of period conversion when possible.

DEFINING FACTORS OF PRODUCTION AND PRODUCTS

Economic theory and accounting principles provide the foundation upon which CAR estimates are developed. For economic analysis, the definition of cost is broader than for financial accounting. An "economic cost" is the compensation received by the owners of capital and the units of factors of production, which ensures that the inputs continue to be supplied. The amount of this payment is usually determined by market forces. In some situations markets may not be functioning or no formal market may exist. In these cases, the amount of payment to the factor of production must be determined by other methods. In practice, the measurement of CAR (particularly historical estimates) requires using accounting information because farmers maintain their information in that way. In accounting, CAR are derived using principles that guide the construction of basic financial statements such as the statement of cash flows, the balance sheet, or income statement. In accounting, the concept of actual historical cost is central, but it ignores several important components of economic costs. These items are costs associated with the use of financial (including equity) capital, long-lived factors such as equipment and buildings owned and used by the business, and the contribution of unpaid time and effort provided by the farm operator and family members. Estimates of such implicit costs must be obtained using the economic concept of “opportunity costs”[1].

[1]"Opportunity cost" is defined and discussed further in the next section under "Valuing Factors for which there is no Market Transaction."

Chapter 2. Conceptual Issues in Cost and Return Estimates

Clear definitions and distinctions of the important concepts associated with the measurement of economic CARs as opposed to accounting costs will be helpful in preparing and using CAR estimates. The first set of concepts is related to the physical production process.

> A **production system or method** is a description of the set of outputs that can be produced by a given set of factors of production or inputs using a given production process.
>
> A **factor of production (input)** is a good or service that is employed in the production process.
>
> A **product** is a good or service that is the output of a particular production process.

Economists typically view the production system as a set of outputs and the associated inputs that are capable of producing them, and often assume a continuous production process where alternative combinations of inputs can be used to produce a given level of output. In preparing costs of production estimates, the analyst must specify the production system and the specific input levels used to produce the desired level of output. In other words, the analyst must choose one point in the producible output set on which to base CARs. The typical economic assumption is that the producer will minimize the cost of a given level of output by judicious choice of inputs and technology. For historical estimates, the levels used by the analyst are the actual levels used, whether they represent optimized choices or not. For projected or synthetic estimates, the most common assumption is to choose either a "best management" level of inputs or some "representative" level of inputs. The important point is that for the purposes of CAR estimation the input-output point on the production surface is fixed at either a historical or an "optimal" level, and CARs are estimated as if the technology is of the fixed coefficient "Leontief" type at this point. Estimates based on alternative input-output points can also be constructed for comparison.

Factors of production may be categorized in many ways. A common delineation is between labor and materials, where all inputs other than labor are considered materials. Materials can also be classified in different ways. One common distinction is between primary factors (natural resources such as land and extractables such as oil), which are considered to be nonreproducible, and capital, which is defined as being produced from other factors (labor, primary factors, and other capital). In this sense all produced factors are called capital. A more modern classification differentiates inputs based on stock and flow concepts. This more modern approach defines capital as a stock that yields a stream of services (utility) in the current and future periods. These services have value either as inputs into a production process, for direct consumption, or for sale in the market. The services flowing from a stock of capital are considered distinct from the capital itself. In contrast to capital, factors whose services are exhausted in one period and have no value other than in being used up are called **expendables**.

In the more modern approach, capital refers to stock resources that provide service flows over more than one time period. A number of resources fit this classification: land, equipment, buildings, and machinery are clearly considered capital goods according to this definition. In a more general sense, education and experience—as they enhance the productive capacity of workers—are considered human capital. In a free society, however, ownership of human capital is restricted to the person in whom it is embodied. At a societal level, stocks of knowledge and information are also capital. Some of these stocks can be owned whereas others are in the form of public goods. Legal rights such as the right to remove water from a stream are also a form of capital. Inventories can be considered capital to the extent that they may not be depleted in a single time period.

The production potential of capital can be modified in many ways. These modifications take the form of changes in the service capacity or potential future productivity. Service capacity can be reduced in a variety of ways. This reduction in service potential can be wear and tear associated with the passage of time or use. For example, the roof of a barn deteriorates due to exposure to the elements and the valves on an engine wear out with use. Reduction in service potential might also be due to depletion in the case of natural resources or inventories, obsolescence in the case of knowledge, or deterioration in skills in the case of human capital.

Service capacity can be enhanced by additional investment in the capital asset. Examples include overhauling an engine, reroofing a barn, replacing several sections of a concrete ditch, or terracing an erodible hillside. The service potential of a given stock of human capital can be enhanced by additional education, training, and investment in health; or, it can be reduced by poor coordination and supervision, or extended exposure to damaging environmental factors such as noise, pesticides, and intense heat or cold. Expenditures to enhance the stock of human capital and its service flow can be thought of as analogous to enhancing the service flow of other capital. The increased service capacity is usually embodied in the labor, and thus cannot be owned by anyone else. Owners of capital also take actions that are intended neither to reduce nor to enhance service capacity, but simply to promote optimal productive use. Such actions are usually called **maintenance** or **upkeep**. Examples are lubricating bearings, rotating tires, or mending a fence. Of course these actions do have an impact on long-run service potential and so they must be considered along with wear and tear and service operations in evaluating the productive capacity of a capital asset.

Factors of production are then categorized as being either labor, capital (including land and human capital), or expendables. Since human capital is embodied in the worker, factors are often categorized as being either capital assets or expendables. Capital is useful only to the extent that it provides services. And the services of capital are expendable in the sense that once a given service such as 10 hours of tractor time is used, those specific hours are exhausted. This report makes the following distinctions between factors of production.

> **Expendable factors of production** are raw materials, or produced factors that are completely used up or consumed during a single production period. Common examples of these factors that lose their identity with a single use are seed, fuel, lubrication, some pesticides and fertilizer, feed, and feeder animals.

> **Capital** is a stock that is not used up during a single production period, provides services over time, and retains a unique identity. Examples include machinery, buildings, equipment, land, breeding livestock, stocks of natural resources, production rights, and human capital.

> **Capital services** are the flow of productive services that can be obtained from a given capital stock during a production period. These services arise from a specific item of capital rather than from a production process. It is usually possible to separate the right to use services from ownership of the capital good. For example, one may hire the services of a potato harvester to dig potatoes, a laborer (with embodied human capital) to provide milking services for a given period, or land to grow crops.

A number of examples will illustrate the argument. Land is considered a capital asset, but the right to use the land for a specific period is an expendable service flow. A laborer and the embodied human capital is considered capital, but the service available from that laborer is considered an expendable capital service. Similarly, a professional such as an accountant, veterinarian, or lawyer is a capital good in the sense that he or she provides services over time, but these services are usually hired on a fee per unit of time or project basis. Shares in an irrigation company are considered capital but the acre feet available for use in a given season is an expendable input. There is often a certain arbitrariness in defining an input as expendable versus a capital service. For example, gravel excavated from an on-farm pit could be considered either as the capital service of the stock of gravel or as an output, because it requires a production process (excavation and hauling) to obtain the service. In general, only factors that arise directly from a capital stock should be considered capital services, but some looseness of definition is inevitable.

Some inputs that last more than one period lose their unique identity upon use. Examples include paint applied to machinery and buildings, repair parts, hay fed to dairy cattle, subsoiling, spraying of ditches, application of lime, and fertilizers with no appreciable carry-over. Such inputs are usually not treated as capital but as expendable inputs used to maintain the productive capacity of other inputs. The costs of such inputs are usually allocated (prorated) across the periods they provide service. Inputs such as terraces and tile drains may be handled either as separate capital items, because they are quite unique, or as part of the land base when rented in conjunction with the land. Some factors of production produce more than one kind of service. For example, a fire extinguisher loaded and readily available provides fire protection services. The extinguisher provides these services over time and does not lose its identity in the process (thus fitting the capital category), but when used to put out a fire can be used only once. For this service, the extinguisher may be considered an expendable. The classification factors of production that produce more than one kind of service are arbitrary, but they are commonly considered capital assets because they show up on the balance sheet and provide service flows for more than one period.

Differences in classification of factors are important for valuing their contribution to production. Only the actual value contributed to the production process of a specific output during a given period is considered as a relevant cost for a factor. For capital factors that are employed for several periods, one must make an assumption about the contribution that the factor contributes in each period. For a granary, this may be cubic feet of storage space of uniform quality per period. If the quality of this space is fairly uniform over time and can be maintained in this quality with known annual maintenance, then the cost of granary space per unit of grain stored can be computed as a constant. A tractor may have a known purchased price and salvage value, constant fuel and lubrication costs based on hours of use, and increasing repair costs, also based on hours of use. If the quality of an hour of tractor time (with appropriate repairs and maintenance) does not change over the life of the tractor and the tractor is used the same number of hours per year over its life, then the analyst can compute an annual annuity representing the annual cost of the tractor that can be broken down easily on a per hour of service basis. If the production of a ton of sweet corn using a specific production system requires 3.5 hours of tractor time, then the tractor cost per ton can be computed easily using this constant cost per hour of service.

If the productivity of a capital input depends on its age and level of use, then more complicated procedures are needed. For example, consider a capital asset such as an apple orchard. The orchard will have several years of preproductive costs with no output, including a large expenditure in the establishment year. Once production begins, it will typically rise, reach a plateau, and then fall. The cost per bushel for the apples for each year will vary depending on the number of years the orchard is in production, the yields per year, and the operating costs. In this case it is not reasonable to compute a constant capital cost per bushel as with the granary or possibly the tractor, because the productivity of the orchard varies over time. Instead, it makes sense to develop a unit cost of capital that varies with time. Cost of production studies typically assume constant productivity across time for most inputs including machinery, equipment, and buildings. The justification for constant productivity of machinery is that appropriate and increasing repair expenditures can compensate for decreased service capacity. This assumption is probably reasonable in most situations but should be evaluated on a case-by-case basis. The assumption of constant productivity is much less reasonable in the case of breeding livestock, most perennial crops, some types of wells, and some land or range resources. This report will generally compute capital costs for machinery, equipment, and buildings assuming constant productivity over time. Discussions of appropriate ways to handle variable productivity are contained in Appendix 6A and in Chapter 10 on multiyear enterprises.

VALUING FACTORS OF PRODUCTION

The economist's classical theory of the firm distinguishes between owners of resources and the operator of the firm. The firm is viewed as purchasing expendable inputs such as seed, fuel, and feed, and capital good services such as hours of labor and human capital, machinery and equipment, or the services of land, buildings, and other structures, in exchange for fixed payments. When these inputs can be used over several production periods, the owner of the firm pays a fixed fee for use in a given period. Thus, the actual costs of inputs can be determined by market prices and quantities or expenditures, if the market is assumed to value correctly the contribution of any good or service to the welfare of economic agents. For example, the cost of seed depends on the price per pound and the number of pounds used, the cost of land per acre is the rental rate, the cost of machinery per hour is the custom rate, and the cost of human capital is the wage rate times hours worked or compensation including benefits. In this framework, all factors of production except the operator of the firm are compensated in full for their contribution.

> ***The Task Force recommends that when there are active markets for a given factor of production and there are no constraints on factor use, the preferred value to use for all CAR estimation is the current market price (or compensation) of that specific factor.***

Although the valuation of homogeneous factors traded in active markets is straightforward based on this recommendation, numerous complications arise in practice when factors are not homogeneous and/or not purchased in a competitive market. The remainder of this section will consider general valuation principles for factors of production. After discussing time preferences, interest, and inflation in the following section, a more complete analysis of some of the more complicated issues will be presented.

Valuing Factors that Differ in One or More Attributes

The economic law of one price applies to goods and services that are exactly the same in all relevant dimensions. Some of the most common dimensions are quality, time, and space.

Clearly, costs and revenues must be adjusted to account for quality differentials such as discounts for damaged produce. A discussion of some of these issues, particularly with respect to products, is contained in Chapter 3: Revenues and Government Programs Participation. Issues related to time are discussed in the next major subsection.

With respect to differences in location, it is important to include as a cost of producing and marketing the product, the cost of getting the product to the market from which the product price is obtained. Conversely, the price can be adjusted to compensate for this expense. Otherwise, the net returns to the firm will be overstated. Spatial equilibrium implies that price differences across location of commodities that are otherwise identical should be equal to transportation costs.

> ***The Task Force recommends that all CAR estimates should reflect goods and services that are identical, or that are cost-adjusted (revenue-adjusted) for any differences in location, quality, or time of delivery.***

Valuing Expendable Factors that are Purchased

A purchased expendable factor is bought and used during the current production period and so its cost is obtained by multiplying the quantity used by the market-determined purchase price. If there are volume or other discounts or additional payments such as fringe benefits for workers, these should be considered in computing the cost. Adjustments for time, quality, and location should also be made in keeping with the idea of pricing all inputs and outputs at a uniform quality level for a given price, at the same time, and at the same place. More specific discussion on expendable inputs is contained in Chapter 4.

Valuing Capital Services that are Purchased

The market price for capital services is the appropriate charge for CAR estimation if the owner of the capital is distinct from the operator of the firm and the capital services are obtained in a market transaction. All of the adjustments for time, quality, and space, as in the case of expendable factors, apply here as well.

Valuing Factors for which there is no Market Transaction

When the operator of the firm is also the producer of an expendable input used in the production of another output or the owner of the capital used to provide a service, there is no market transaction to reflect the cost of using these factor services, and an implicit cost and revenue must be computed because no market transaction takes place. This situation requires use of the concept of opportunity cost.

> The **opportunity cost** of any good or service is its value in its next best alternative use. For example, the opportunity cost of the service of an input used in the production of any particular commodity is the maximum amount that the input would produce of any other commodity. Opportunity costs are usually measured in monetary terms so that the opportunity cost of any good or service is the maximum amount the good or service could receive elsewhere for use as a production input or for final consumption.

When a market transaction is not available to value a given expendable factor or capital service, methods that will approximate the opportunity cost of the service are used. These methods are not as reliable as direct market valuation; therefore, as long as well established (or regular) markets exist for the given services and the amount of service that is used can be determined, the best estimate of the cost for the services of an operator-owned factor in preparing CAR estimates is the market price of that factor service. But when markets are nonexistent or very "thin," the other methods of estimating costs associated with the ownership and use of an asset must be employed to approximate the market solutions. These methods usually take the form of using market prices for similar expendables or determining implicit rental rates for capital services.

Valuing Produced Expendables

Produced expendables utilized on the farm should be valued at the cost of purchasing the factor from off-farm as the cost of the factor to a utilizing enterprise because this reflects the opportunity cost of the factor to the utilizing enterprise. As an example, consider a farmer who raises feeder pigs for use in a finishing operation. The appropriate cost for these feeder pigs to the finishing operation is the cost of purchasing the pigs off the farm. An alternative for the factor cost is the price the farmer could obtain for the feeder pigs if they were sold in the local market. Alternatively, consider a dairy farmer who produces more corn silage than needed for his dairy herd and who sells the excess to a neighbor who picks it up on the farm. The price the neighbor pays for the silage is an estimate of the value of the corn silage to the dairy enterprise.

Valuing the Capital Services of Owned Capital

Capital services provided by the owner of the operation of a given enterprise should be valued at the cost of obtaining these services from an alternative source in an arms's length market transaction. For example, in situations where there are active cash rental markets for land, these rental rates provide a good estimate of the cost of land services. In situations where cash rental arrangements are not common, share rental rates can sometimes be used to approximate the actual factor cost. In some states there are active markets in machinery rental that can be used to approximate factor cost of machines, although in much of the country such markets are very small and specialized. In many areas, a number of capital services are offered on a custom basis. These custom rates provide an estimate of the cost of the capital service. There are few situations where an active market in general purpose buildings exists. In the case of labor, there may be active markets for unskilled workers allowing use of commonly reported wage rates; however, the market for skilled managers may be much smaller, requiring the use of opportunity cost calculations.

> ***The Task Force recommends that market-determined costs of inputs should be used when they are available and that other methods should attempt to reflect what the market solution would be if it existed. In general, the cost of purchasing inputs from off the farm as opposed to their on-farm production cost should be used in pricing these inputs to other on-farm activities. Similarly, custom rates for machinery should be used when markets for these items are well established and custom operations can be performed in a timely manner.***

These other market-based methods should reflect the CARs associated with the long-term ownership of assets and the market-determined equilibrium cost of obtaining the factor services of those assets.

Accounting for Transactions Costs

In markets with no transactions costs, the purchase and sale price of a given good or service will be the same. Most markets, even those that operate efficiently, will have some transactions costs associated with minimal transportation, brokerage and handling fees, short-term storage, insurance premiums, checkoff assessments, shrinkage, or other loss. A common example is the difference between the buy and sell price at a grain elevator. When transactions costs are not zero, the purchase price of a factor will exceed the sale price by the transactions costs. The correct value to use in assessing the return to the selling enterprise, assuming outside sale, is the sales price net of any transactions costs assumed by the seller. Alternatively, the actual selling price can be used and the transactions costs included in the cost of production. The cost of a factor purchased from outside the firm is the purchase price plus any additional transactions costs assumed by the buyer. If there are unavoidable costs associated with getting a product to market, they should be included as a cost of production. If the product is used internally, these costs should not be included, however. Similarly, if there are costs associated with purchasing a product externally, they should be included when the product is purchased externally but ignored if obtained internal to the firm. The price used for internal transactions should be conceptually the same for both purchase and sale because the factor (product) is at the same time and place at the point of internal sale. The difficulty is that market prices are often for the good or service at a slightly different time or place, and perhaps in a different form. Simply using the market price may implicitly attribute a higher return to one of the enterprises because the actual costs of getting the product to or from the market may not be the same and may not be explicitly counted in the costs of either enterprise.

To make the issue of transactions costs clear, consider an example where the market price of a feeder steer at the local auction market is $250. Assume the cost of transporting the steer from the farm to or from the market is $15 so that the implicit price at the farm is $235. All other costs of production for the feeder steer are $200 so that the net profit to the feeder steer enterprise is $35. The auction charges a fee of $5 which is paid by the buyer of the feeder steer. If all feeder steers produced on the farm are sold at this market then gross revenue to the feeder steer enterprise is $250 and the net price is $235. If the costs of transportation are not explicitly included in the estimate then the net price should be used as the sale price per head for the feeder steer enterprise. Suppose the slaughter steer enterprise on the same farm purchases the feeder steers. The purchase cost of the feeder steers produced on the same farm is $235 per head, assuming no transportation costs. If the slaughter steer enterprise purchases some or all feeder steers at the local market (assuming no closer available source), then the total cost of the purchased feeders steers is $270 (250+15+5). Assume that the revenue minus all other costs for the slaughter steer enterprise is $350. Then the net revenue for the slaughter steer enterprise for the purchased feeder steer is $80, and the net revenue for the slaughter steer enterprise on feeders transferred from the feeder steer enterprise is $115 ($350-235) per head. Using the site-specific net price of $235, the feeder steer enterprise has returns of $35 and the slaughter steer enterprise has returns of $115. The site-specific price is the opportunity cost of the feeder steer produced on the same farm and it is the recommended method of valuing those steers. An alternative method of valuing the feeder steers produced on the farm is to use the market price of $250 as both the selling and buying price. This method may be used when the transportation and auction charges are not well documented, making calculation of the site-specific price somewhat arbitrary. Although the site-specific method has some theoretical backing, assuming well-functioning markets, there is arbitrariness in any such allocation.

> ***The Task Force recommends that, when transactions costs are small, for simplicity, the local market price be used to value the factor (product) and transactions costs not be charged to either enterprise. When transactions costs are large, it is more important that the allocation rule chosen not distort relative factor returns. In such cases, the allocation rule used should be made explicit and the sensitivity of the results to the allocation rule discussed.***

A more detailed discussion of allocation rules for handing transfer pricing is contained in Chapter 4: Purchased and Farm-Raised Expendable Inputs. Before considering valuation of these various types of factors in more detail, some discussion of adjustments to both expendable and capital costs to account for time differences is needed.

TIME PREFERENCES, INTEREST, AND INFLATION

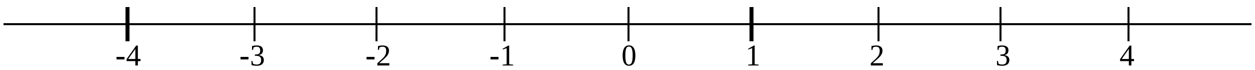
Most agricultural production occurs with a time lag so that costs are often incurred months or even years before the end product is completed and sold. Some factors of production (a tractor, for instance) are used to produce many sets of output over many different production periods. In order to make sense of CARs that occur at different points in time and combine them effectively to make optimal decisions, a clear understanding of issues related to time preferences and interest rates is important. Dealing with this time lag is one of the thorny issues in CAR estimation.

Individuals have preferences over the timing of CARs. Economic theory usually assumes that an individual has a positive rate of time preference, meaning that one dollar today is preferred over one dollar one year from now. This is usually attributed to impatience or quasi concavity of the utility function. Exceptions to this positive rate can occur easily if relative income and wealth levels differ across time periods, if financial markets are not complete, or if there are significant costs for carrying goods between periods. The rate of time preference for an individual commodity is the implicit relative price that would induce an individual to consume or hold equal amounts in adjacent periods and is implied by the shape of indifference curves. When applied to an individual commodity, the rate of time preference is called the **own rate of interest**; when applied to a numeraire commodity such as money, it is called the **discount rate** or the **rate of interest**. Just as the interaction of individual preferences for commodities and the production technology determine the relative prices of goods, the interaction of individuals' time preference, commodity preference, and the technology determine a market rate of discount or interest rate. There are clearly different discount rates for time periods of different lengths. These rates reflect the market's evaluation of the relative worth of the same income flows (or money) occurring in different time periods.

An individual's rate of time preference is determined independently of the market rate of interest, but is a factor in determining the market rate. In an economic equilibrium, where individuals can trade freely on commodity and financial markets, they will make production and consumption decisions such that (at the margin) their individual rate of discount between income in different periods is equal to the market rate of interest. The Fisher separation theorem (Copeland and Weston: 11-12) implies that production decisions can be made independently of consumption decisions when markets are complete. This theorem further implies that individuals will make production decisions based on this market rate of interest, and partially justifies the common practice of using the market rate of interest (discount) for evaluating the relative contributions of returns and costs to an individual's welfare at different periods in time. When markets are not complete or fully functioning, a rate of discount other than the market rate may be applicable. This may be particularly important when estimating costs for individual firms when full access to financial markets may not be available or the risk characteristics of the firm make published discount rates inappropriate.

Discounting CAR Flows

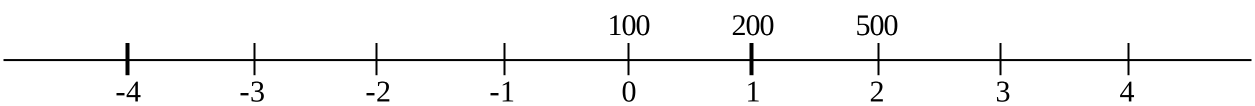
The practice of adjusting all CAR streams to a common point in time to account for time preferences is usually called discounting or present value analysis. The idea is that with properly functioning markets, funds received in one period can be invested at the market discount rate and earn that rate of return over the period. Thus one dollar received today is worth more than one received tomorrow because it can be invested at this usually positive market rate. In CAR estimation, it is important to reflect the value of all CARs at a common point in time so that the values are strictly comparable. If the desire is to reflect all future monetary flows on an equivalent current period basis, **present value formulas** are used. When income streams are adjusted to a future point in time, the practice is sometimes called **compounding** or **future value analysis** to contrast it with **discounting** income flows back to the current period. This report will use the terms **present value analysis** and **discounting** to reflect any adjustments of income streams to account for time preference, whether these adjustments are forward or backward from the base period. The literature on capital budgeting and financial decision making provides a useful reference for this discussion (Copeland and Weston; Lee; Levy and Sarnat). In order to make the analysis clear, consider a number line taking values from -4 to 4 as below. Time 0 is considered to be the present time, time 1 is one period in the future, -2 is two periods in the past, and so forth.



Of course, the line can be renumbered so that any point on it is time 0. Consider now an income (cost) stream that begins at the present time 0 (or the beginning of the first period) and ends at time n. The value of this stream at time 0 is given by

$$V_0 = \sum_{t=0}^{n} \frac{R_t}{(1+i)^t} \tag{2.1}$$

where V_0 is the present value of the payment stream (of income or costs) on the right-hand side of the equal sign. The notation R_t represents the net return or cost at the end of period t, where t denotes the time period 0, 1, 2, 3, ..., n. The discount rate, which is constant over time, is given by i. If the initial period of the income stream is considered to be the base, as in this example, the discounted value is called the present value of the future income stream. For example, consider an income stream with values (100, 200, 500) at the points 0, 1, and 2. This is represented on the number line by placing the returns above the line as follows.



The present value at point 0 of the above stream is given by

$$V_0 = 100 + \frac{200}{1+i} + \frac{500}{(1+i)^2}\,.$$

If the interest rate is 5%, this will give

$$\begin{aligned} V_0 &= 100 + \frac{200}{1.05} + \frac{500}{(1.05)^2} \\ &= 743.991\,. \end{aligned}$$

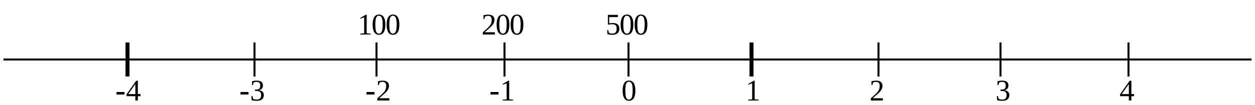
In many instances it is useful to adjust CARs to points in time other than the present. This can be accomplished using the above formula and allowing the index t to take on both positive and negative values in relation to the point of time considered to be the present or the base (0) for the analysis. For example, consider adjusting all income flows to the end of the last period (the n^{th} period) as is done in future value analysis. The value at the end of the n^{th} period (V_0) of a CAR stream occurring over the n periods is given by

$$V_0 = \sum_{t=-n}^{0} \frac{R_t}{(1+i)^t} \qquad \textbf{(2.2)}$$

where V_0 represents the value of the payment stream at the end of the period (time 0). If one prefers to use positive values for the index t and treat the n^{th} period as the base, as in standard future value calculations, the above formula would read

$$V_n = \sum_{t=0}^{n} \frac{R_t}{(1+i)^{t-n}} = \sum_{t=0}^{n} R_t \, (1+i)^{n-t} \,. \qquad \textbf{(2.3)}$$

The value on the right-hand side of 2.2 and 2.3 remains the same, but is represented in a slightly different way. For example, suppose the above stream of returns is to be evaluated at the end of the second period (at point 2 on the original line). The line can be renumbered, making the end of the second period (point 2 on the original line) point 0, as shown below



where 100 occurs at -2 and 500 occurs at 0. The present value at point 0 is

$$V_0 = \frac{100}{(1+i)^{-2}} + \frac{200}{(1+i)^{-1}} + 500$$
$$= 100(1+i)^2 + 200(1+i) + 500 \,.$$

Sometimes it is useful to value an income stream at a point in the middle of the time horizon. For example, one might choose the end of the current year as the point to value CARs for a cow-calf operation even though returns occur next year. In this case, rather than continually modifying the formulas and notation, it may be simpler always to consider the point in time to which the streams are adjusted to be zero in the sense that the discount factor for the period has an exponent of zero and number all periods from that point so that future periods have a positive index (and positive exponent on the discount factor) and prior periods have a negative index. In this case the formula to discount the return streams to the k^{th} period is given by

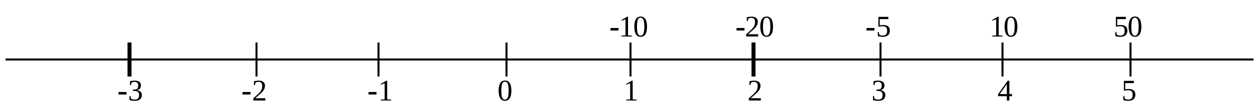
$$V_k = \sum_{t=j}^{n} \frac{R_t}{(1+i)^{t-k}} = \sum_{t=j}^{n} R_t \, (1+i)^{k-t} \qquad \textbf{(2.4)}$$

where j is the first period considered and n is the last. When k is greater than t, flows are adjusted forward to period k; when k is less than t, flows are adjusted back to k; and when k is equal to t, the flow is not adjusted. Consider the value at the end of the first period (or time 1 on the number line) for the above payment stream. The formula will give

$$\begin{aligned} V_1 &= \sum_{t=0}^{2} \frac{R_t}{(1+i)^{t-1}} \\ &= \frac{100}{(1+i)^{(0-1)}} + \frac{200}{(1+i)^{(1-1)}} + \frac{500}{(1+i)^{(2-1)}} \\ &= 100\,(1+i) + 200 + \frac{500}{(1+i)} \end{aligned}$$

where V_1 represents the value at the end of the first period.

To clarify the discussion, consider a stream of CAR flows occurring at the end of each period. Let the flow at the end of period 1 be -10 with a further return at the end of period 2 of -20. Let the returns at the end of periods 3 through 5 be -5, 10, and 50. The number line is as follows:



Assume a discount rate of 10%. The adjusted (discounted) values of each flow and the total for the entire stream at the end of each period are given in Table 2.1 below. The columns give the cash flow adjusted to the end of the period in the column title. For example, consider the first line of the table which reflects cash flow of -10 at the end of the first period. This cash flow has value -10 at the time 1, but declines in value (grows in absolute value) to -11 (11) by the end of period 2. The value at the beginning of period 1 (end of period 0) is -9.091. The adjusted value of this flow at the end of the fifth period is -14.641. Similarly, the value at the end of period 0 of the 50 dollar return occurring is 31.046 and the value of the 50 dollar return at the end of the fifth period valued at the end of the fifth period is 50. The Total row at the bottom of the table gives the total of the cash flows for all periods adjusted to the end of the period in the column title. Thus, for example, the total value of all five cash flows at time 0 is $8.499, while at the end of the first period (time 1) it is 9.35 and at the end of the fifth period it is 13.689. The diagonal elements of the table are the same as the actual cash flows, because the diagonal represents adjustments to that period as the base. Furthermore, the amounts in the Total line can be adjusted to any other period using similar procedures. For example, the value of the entire stream at the end of the fourth period ($12.445) is properly discounted to the end of the first period using the relation $V_0 = 12.445/(1.1)^3 = 9.35$.

TABLE 2.1 Discounted Values of a Cost and Return Stream

Value at Point in Time		0	1	2	3	4	5
Period	Cash Flow at End of Period						
1	-10.000	-9.091	-10.000	-11.000	-12.100	-13.310	-14.641
2	-20.000	-16.529	-18.182	-20.000	-22.000	-24.200	-26.620
3	-5.000	-3.757	-4.132	-4.545	-5.000	-5.500	-6.050
4	10.000	6.830	7.513	8.264	9.091	10.000	11.000
5	50.000	31.046	34.151	37.566	41.322	45.455	50.000
Total		$8.499	$9.350	$10.285	$11.313	$12.445	$13.689

The point is that all CAR streams can be adjusted to reflect the same point in time using an appropriate discount rate. These adjusted CARs can then be summed to compute net income, return on investment, and other financial measures.

Measuring Growth Rates of Economic Variables and Compounding of Interest

When analyzing economic variables that are growing over time, an important issue is how to measure the rate of growth. Growth rates are usually expressed as a percentage rate over some time period. For example, if average corn yields in a county were 100 in 1980 and 110 in 1990, the growth over the ten-year period is 10% ({110-100}/100). The annual rate of growth is not 1%, however, because if yields were 100 in 1980 and 101 in 1981, a 1% growth rate would imply yields of 102.01 [(101)(1.01)] in 1982, 103.03 in 1983 and 110.46 in 1990. This is of course due to the compounding of the growth over time. The annual rate of growth that is consistent with a 10% rate of growth over the ten-year period is .9576% because $(100)(1.009576)^{10} = 110$. Thus when computing growth rates of any type, a period for compounding the rate must be considered and be made explicit in the analysis. For example, one can talk of a quarterly rate of growth that is consistent with a given annual rate, an annual rate that is consistent with a biennial rate, etc. For example, a 1% rate of quarterly growth is equivalent to a 4.06% $[\{(1.01)^4-1\}\{100\}]$ rate of annual growth or a 4% rate of annual growth is equivalent to a .9853% $[\{(1.04)^{.25}-1\}\{100\}]$ quarterly growth rate.

Whereas many economic variables have a natural defining time period, such as yields for an annual crop, for others the appropriate period is not always obvious or even the same for different types of questions. For example, it is not clear whether an annual rate of productivity growth is appropriate for broiler or almond production. In analyzing the growth of farm income, monthly, quarterly and annual rates all make sense for different types of questions. When considering financial variables where interest (and discount) rates are often applied, it is crucial to decide the appropriate period for compounding and correctly convert subperiod rates to annual rates and vice versa. This is especially important when some variables may earn interest under different compounding rules such as daily versus monthly versus annual compounding in the case of production loans.

Real and Nominal Magnitudes

The value of a commodity can be expressed in terms of other goods or in terms of prices (dollars). When commodities are measured in terms of other commodities or in terms of their purchasing power, the stated value is in real terms since it reflects the "real" purchasing power of the commodities. When the value is stated in terms of current prices, the value is in nominal terms. For a single commodity, real values can be expressed in terms of bilateral exchange ratios or in terms of a numeraire commodity. The most common numeraire is the price of money in some base period. For example, the relative price of corn and soybeans can be stated as 2 bushels of corn for 1 bushel of beans or, alternatively, that corn sells for $2.50 and soybeans sell for $5.00. For aggregate output, real magnitudes are expressed in terms of some base period price level. Thus for example, we talk about real Gross Domestic Product (GDP) as being current output at base period prices. So, nominal magnitudes reflect values in current period prices and real values reflect values in base period prices. The change in the overall price level between any period and the base is called the **general rate of inflation**. When the overall price level does not change between periods, real and nominal values will be the same. Just as with other prices, real interest rates are specified in terms of some base period and nominal interest rates are stated in terms of the current period. In an economy with constant prices (no inflation), the market-determined rate of interest is both a real and a nominal rate. When there is inflation, the real and nominal rates of interest differ because the higher price level in later periods reduces the future value of other goods in relation to the numeraire good (money). When interest rates are specified in terms of the current monetary unit, the nominal interest rate on a loan is more than the real rate (when inflation is positive) because the real cost of a loan is less than the nominal cost.

Real and nominal rates of interest are related by the Fisher equation. If p is the inflation rate between two periods, r is the real interest rate and i is the nominal interest rate, then the following identity (Copeland and Weston: 65; Fisher; Patinkin) holds

$$(1 + p)(1 + r) = (1 + i). \qquad \textbf{(2.5)}$$

Notice that $(1+i) \neq (1+p+r)$ because inflation and the real interest rate interact over the time period. Specifically, the interest rate applies to the inflating dollars, not just the beginning of period dollars. When r and p are small, (1+p+r) is approximately equal to (1+i). The Fisher relation can be rewritten to solve for the nominal interest rate, i, as a function of the real rate, r, and the inflation rate, p, as

$$i = r + \pi + \pi r \qquad \textbf{(2.6)}$$

or for the real rate as a function of i and π as

$$r = \frac{(i - \pi)}{(1+\pi)} = \frac{(1 + i)}{(1+\pi)} - 1 \qquad \textbf{(2.7)}$$

or for the inflation rate as a function of i and r as

$$\begin{aligned} \pi &= \frac{(1 + i)}{(1+r)} - 1 \\ &= \frac{i - r}{(1 + r)} \end{aligned} \qquad \textbf{(2.8)}$$

where all rates are stated for the same time period and there is no compounding of interest within the stated periods[2]. For example, with an annual inflation rate of 5% and a nominal interest rate of 8%, the implied annual real interest rate is (1.08)/(1.05) -1 = .0286. Similarly, with an inflation rate of 5% and a real rate of 3% the implied nominal annual interest rate is 8.15 %.

The nominal rate of interest is appropriate for use in comparing nominal magnitudes, but the real rate is correct for use in comparing real magnitudes. The nominal rate is, of course, made up of the real rate and an inflation adjustment. Adjustments to cash flows for time preference thus have a component related to the real interest rate or the real cost of holding money and a component related to changes in prices due to inflation. The combined effects of the inflation component and the real interest component can be calculated using the nominal interest rate. It is appropriate to use the nominal interest rate to discount nominal CARs within a given production year as long as all the analysis proceeds on a nominal basis. These adjustments can be arbitrarily divided into real interest and inflation components.

> ***The Task Force suggests that, when CAR estimates are computed on an annual basis in nominal magnitudes, the nominal interest rate be used to adjust all within-year magnitudes to a common point in time. As mentioned earlier, the Task Force recommends that this point in time be the end of the production period or the end of the year, whichever is sooner. The Task Force further recommends that the estimates explicitly state this nominal rate, and the items and length of time to which it applies.***

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[2]If interest is continuously compounded, then the Fisher relation is given by $i = e^{\pi t}e^{rt} - 1$ where t is the number of periods of compounding and π and r refer to the inflation and interest rates per period. Thus if annual inflation is 5% per year and the interest rate is 3% per year, the implied annual nominal rate is 8.33%, which is higher than the rate of 8.15% computed using annual compounding.

Once production period values are adjusted to a common point in time using a nominal discount rate, they can be decomposed into real and inflation components or converted to real terms for comparisons among periods, for long run analyses, or for capital budgeting, etc. If the end of the production period is used as the base period for prices, then the end of year prices/costs or returns are both a nominal magnitude and a real magnitude in these year-end prices.

Whether economic analysis should be performed on a nominal or a real basis is an often debated issue. As long as the analysis is performed in a careful and accurate manner, it is immaterial which approach is used as far as the end result is concerned. There are often reasons for performing it in one way or another, usually to be comparable with other estimates. The issues relate to ease of computation, interpretation, and comparison. It is sometimes easier to interpret real magnitudes because inflation distortions are eliminated, but more commonly it is easier to interpret nominal magnitudes because that is the way most values are reported. For example, in considering net farm income per farmer in 1920 to evaluate the welfare of today's farmers, it is probably better to consider this in real terms so that what the income will buy is the same. But if one is interested in obtaining a production loan, the nominal projected value of this year's income is the easiest value to use. In addition, some issues such as taxes and subsidy payments are related explicitly to nominal magnitudes. If returns are changing over time due to inflation, then performing analysis with nominal return values and nominal interest rates will give the same present value as using real returns and real interest rates. This becomes clear if one rewrites equation 2.1 assuming that all magnitudes are real. The discounted value of a real return stream at time 0 is

$$V_0^r = \sum_{t=0}^{n} \frac{R_t^r}{(1+r)^t} \qquad \textbf{(2.9)}$$

where R^r_t is the real return at time t, V_0^r is the real present value of the value stream using a real discount rate, and r is the real interest rate. If the inflation rate is given by *p*, then the nominal return at time t, assuming that the base period is period 0, is given by $R_t = R^r_t\,(1+p)^t$. For example, if the real return in the first period is $300 and the inflation rate is 4% then the nominal return for the period is $312. If the real return in the second period is again $300 and inflation is unchanged, then the nominal return relative to the base period is $(300)(1.04)^2$ = $324.48. Alternatively, a nominal return of $324.48 in the second period is equivalent to a real return of $300 because $324.48/(1.04)^2$ = 300. Now consider a nominal return stream obtained using the above relations and then discounted by a nominal interest rate. This gives

$$\begin{aligned} V_0 &= \sum_{t=0}^{n} \frac{R_t}{(1+i)^t} \\ &= \sum_{t=0}^{n} \frac{R_t^r(1+p)^t}{(1+r)^t\,(1+p)^t} \\ &= \sum_{t=0}^{n} \frac{R_t^r}{(1+r)^t} \\ &= V_0^r \end{aligned} \qquad \textbf{(2.10)}$$

which is the same as real present value in equation 2.9. The value stream in real terms, V_0^r, and the value of the stream in nominal terms, V_0, are the same because we are considering point 0 to be the base for the computation of real values. **Thus real and nominal discounted values will be the same if the base period for the real values is the period to which the flows are discounted.** If a given investment is subject to different rates of inflation than the general rate, then the above analysis must be modified so that the real rates of return to this asset reflect its returns relative to other assets in the economy. Cost and return estimates often assume that the goods under question are subject to the same rates of inflation as other goods in the economy and so these problems are not a real issue. Given the long run trend toward declining relative prices in agriculture, this common assumption should probably be reconsidered. An alternative, as suggested later in this report, is to conduct all analysis outside the current period in real terms.

Implicit and Explicit Interest Charges and Time Adjustments for Within-Period CARs

Implicit and Explicit Discounting of CAR Flows

The market rate of interest is important not only for adjusting CARs received in different periods, but also for computing the explicit and implicit interest charges accumulated on financial capital used to carry out the firm's operations. Most farming enterprises apply inputs during a time period and receive revenues at the end of the period. Such CARs must be accumulated to a common point in time to make them comparable for decision making. As stated earlier, ***the Task Force recommends that projected CARs establish the end of the production period as the reference point in time.*** This means that all expenditures and revenues should be accumulated to the end of the production period using time adjustment calculations. If all costs were incurred at the beginning of the year and all revenues received at the end, this would entail multiplying all costs by (1+i) where i is the nominal market rate of interest. Because revenues are assumed to occur at year end, they would not be adjusted. Because costs and revenues do not conveniently occur at the beginning and the end of the period, some adjustments for timing and compounding must be made.

There is a different market rate of time discount between time periods of different lengths. For example, there are one-month rates, one-year rates and five-year rates of discount. The rate most commonly quoted is the annual rate, and that is the rate assumed unless otherwise stated. Rates for longer periods are related to the rates for shorter periods, but the relationship is not additive as was discussed in the section on growth rates of economic variables. Interest can be calculated over periods different than the one to which the rate applies using the simple rate or using compounding. Compounding is theoretically correct in almost all situations and so is the suggested procedure. The correct interest charge with compounding in effect is given by the following general formula

$$ic = R(1+i)^k - R \qquad \textbf{(2.11)}$$

where ic is the interest charge, R is the amount of a cash flow at the beginning of the first period, i is the constant interest or discount rate for a single period, and k is the number of periods. For example, the interest charge on \$500 for six months with a 1% monthly rate, compounded monthly, is given by $\{500(1.01)^6 - 500\}$

= $30.76. If there were no compounding the charge would be {500(1.06) - 500} = $30.00. A compounded one-month rate compatible with a given annual rate is not that annual rate divided by 12, but is given by the formula

$$(1 + i_m)^{12} = (1 + i) \quad \Rightarrow \quad i_m = (1 + i)^{\frac{1}{12}} - 1 \qquad \textbf{(2.12)}$$

where i is the annual rate and i_m is the monthly rate compatible with the given annual rate i. In a similar fashion, the annual rate consistent with a given monthly rate can be computed using the formula

$$i = (1 + i_m)^{12} - 1 . \qquad \textbf{(2.13)}$$

Similar formulas hold for other compounding periods.

Some examples may help clarify the above formulas. If the one-month rate is 1%, then the equivalent annual rate assuming compounding is $(1.01)^{12}$ - 1 = 12.6825% and not the simple annual rate of 12%. The monthly rate equivalent to an annual rate of 12% is $(1.12)^{1/12}$ -1 = 1.009488 -1 = .009488 = .9488%. The annual interest on a one-year loan of $500 with a monthly interest rate of 1% is $500(1.01)^{12}$ - 500 = 563.41 - 500 = $63.41. Alternatively, the annual interest on a $500 loan with 12% annual interest and no compounding (or .9488% monthly interest with compounding) is $60.00.

Now consider the case of a cash expenditure (loan) that is made with some months remaining in the year where compounding is assumed to take place monthly and the monthly rate is known. The interest that will be due on the loan at the end of the year is given by the formula

$$ic = R(1 + i_m)^n - R \qquad \textbf{(2.14)}$$

where n is the number of months remaining in the year (the number of months the loan is outstanding). For example, consider a loan of $500 held for six months from the beginning of the year. The interest charge assuming a 1% monthly rate of interest is $500(1.01)^6$ - 500 = $30.76. If this amount plus the original amount of $500 were held an additional six months until the end of the year, the total interest would be $530.76(1.01)^6$ - 500 = 563.41 - 500 = $63.41, which is the same interest that would accrue if the loan were held for one year instead of six months.

The Task Force recommends that, when a monthly interest rate is given, interest be computed using the following formula:

$$ic = R(1+i_m)^n - R$$

where ic is the interest charge, R is cash flow at the end of a given month i_m is the monthly interest rate, and n is the number of months interest on the cash flow will be charged.

Similarly, the appropriate **discount factor is $(1+i_m)^n$** where n is the number of months to the end of the year.

Often the rate used in preparing CAR estimates is the annual rate of interest. In this case an equivalent monthly rate must be determined in order to adjust expenditures and revenues to a common point in time. As stated above, the appropriate formula is given by equation 2.12 and the relevant interest charge on a loan (or opportunity cost on a cash expenditure) made during the year is computed by substituting equation 2.12 into equation 2.14 as follows:

$$\begin{aligned} ic &= R\left(1+(1+i)^{\frac{1}{12}}-1\right)^n - R \\ &= R(1+i)^{\frac{n}{12}} - R \end{aligned} \qquad \textbf{(2.15)}$$

where i is the annual interest rate and n is the number of months the cash flow is being adjusted. The interest on \$500 with an annual rate of 12% when held for six months is given by $500(1.12)^{6/12} - 500 = \$29.15$, which is lower than the interest charge of \$30.76 that would result if the monthly rate were 1% because the implied monthly rate with an annual rate of 12% is .9489%.

The Task Force recommends that, when the annual interest rate is specified, the equivalent monthly rate be computed using the formula $i_m = (1+i)^{1/12} - 1$ and that interest charges be computed using this rate as the monthly rate or that the direct formula $ic = R(1+i)^{n/12} - R$ be used. Similarly, the appropriate discount factor is $(1+i)^{n/12}$ where n is the number of months to the end of the year.

A Comparison of the Recommended Method of Discounting with Two Alternative Methods

When loan lengths or discount intervals are less than a full period, two other practices have been commonly used. The first is to compute interest (or the time value adjustment) based on the per period rate and the applicable proportion of the period and not include compounding for subperiods. This means that if the interest rate is stated as an annual level, the rate for different subperiods will be the proportion of the year over which the cash flow is discounted, multiplied by the annual rate. Specifically, for a loan held for n months the approximate interest charge is

$$ic \approx R(1 + (\frac{n}{12})(i)) - R \qquad \textbf{(2.16)}$$

where n is the number of months loan is outstanding. So if the loan amount is \$500 with an annual rate of 12% and the loan is made for six months, the interest charge would be given by ic = 500(1 + .06) - 500 = \$30.00. This method gives a higher interest charge than the correct method (which implied interest charges of \$29.15) even without compounding because the implied subperiod interest rate is higher than the correct rate.

The second method that is occasionally used is to compute a proportional monthly rate and then use monthly compounding. Specifically, for a loan held for n months the approximate interest charge is

$$ic \approx R(1 + (\frac{1}{12})(i))^{n} - R \qquad \textbf{(2.17)}$$

where n is the number of months the loan is outstanding. So if the loan amount is \$500 with an annual rate of 12% and the loan is made for six months, the interest charge would be $500(1.01)^{6}$ - 500 = \$30.76. This method gives a much higher interest charge than the correct method (which yielded an interest charge of \$29.15) because the implied subperiod interest rate is higher than the correct rate and is compounded. This second method is seldom used and is not recommended.

In order to clarify issues regarding discounting, consider an example: a farmer produces cotton and wants to compute the costs of fertilizer, seed, and insecticides. Production begins in February and ends the first of December. The expense items, time of use, and actual costs are given in the first three columns of Table 2.2. The total cost of the items is \$101.73. The interest on each is computed using the formula ic = $R(1+i)^{(n/12)}$ - R. For example, the interest cost for the cotton seed is given by 17.28 $(1.1)^{8/12}$ -17.28 = \$1.13 and the interest cost of the last insecticide treatment is $20(1.1)^{3/12}$ - 20 = \$0.482. The total of these interest charges is \$5.09. Total costs are then given by the sum of actual and interest costs for a total of \$106.823.

TABLE 2.2 Suggested Method of Computing Within-Year Interest Charges

Enterprise termination date is 1 Dec.
Implied monthly nominal rate of interest is applied to actual expense with compounding
Annual nominal interest rate is 0.10 = 10%
Implied monthly nominal interest rate is $\left[(1+0.10)^{\frac{1}{12}} - 1\right]$ = 0.007974 = 0.7947%
Interest charge = (Actual cost)$(1+i)^{n/12}$ - (Actual cost)

Item	Time of Use	Actual Cost	Months of Use	Nominal Interest Charge
Fertilizer	1-Feb	$24.45	10	$2.021
Cotton Seed	1- Apr	$17.28	8	$1.134
Insecticide	1-Jul	$20.000	5	$0.810
Insecticide	1-Aug	$20.000	4	$0.646
Insecticide	1-Sep	$20.000	3	$0.482
Total		$101.73		$5.093
Total Actual Cost + Interest		$106.823		

In alternative method 1, presented in Table 2.3, a proportional nominal interest rate representing the number of months the loan is out is used, assuming no compounding during the year. The interest on each expense item is computed using the formula ic = [R(1+(n/12)(i)) - R] where n/12 is the proportion of the year for which the interest is calculated. For example, the interest on the cotton seed is given by [17.28 (1+ (8/12)(0.1)) -17.28] = $1.152 and the interest on the fertilizer is given by [24.45(1 + (10/12)(0.1)) - 24.45] = $2.038. The total interest charge is given by $5.19, which is larger than before because a proportional rate implies a higher interest charge for subperiods. The total costs of $106.92 are also higher by this increased interest charge.

TABLE 2.3 Alternative Method 1 for Computing Within-Year Interest Charges

Enterprise termination date is 1 Dec.
Proportional monthly nominal rate of interest is applied to actual expense with no compounding
Annual nominal interest rate is 0.10 = 10%

Implied monthly nominal interest rate is $\left[(1\%(\frac{1}{12})(0.10))\&1\right]$ = 0.008333 = 0.8333%

Interest charge = $\left[(\text{Actual cost})\,[1\%(\frac{n}{12})(i)]\right]$ - Actual cost

Item	Time of Use	Actual Cost	Months of Use	Nominal Interest Charge
Fertilizer	1-Feb	$24.45	10	$2.038
Cotton Seed	1- Apr	$17.28	8	$1.152
Insecticide	1-Jul	$20.000	5	$0.833
Insecticide	1-Aug	$20.000	4	$0.667
Insecticide	1-Sep	$20.000	3	$0.500
Total		$101.73		$5.19
Total Actual Cost + Interest		$106.92		

In Table 2.4, alternative method 2 uses a proportional nominal monthly interest rate along with compounding during the year. In this method a proportional monthly rate is calculated and then used as in the base case. The interest on each expense item is computed using the formula $ic = R(1+(1/12)(i))^n - R$ where n is the number of months that interest accrues. For example, the interest on the cotton seed is given by 17.28 $(1+ (1/12)(0.1))^8$ -17.28 = $1.186 and the interest on the fertilizer is given by $24.45(1 + (1/12)(0.1))^{10}$ - 24.45 = $2.116. The total interest charge is given by $5.328 which is much larger than before because a proportional monthly rate implies a higher interest charge than the equivalent compound rate. The total costs of $107.058 are also higher.

Although the use of proportions is a common practice and easily implemented using hand calculations, the more correct formulas are just as easy to implement using computers and thus are preferred. **If a different procedure than that recommended by the Task Force is used, it should be made explicit in the presentation of results and the magnitude of any approximation errors should be discussed.**

TABLE 2.4 Alternative Method 2 for Computing Within-Year Interest Charges

Enterprise termination date is 1 Dec.
Proportional monthly nominal rate of interest is applied to actual expense with compounding
Annual nominal interest rate is 0.10 = 10%
Implied monthly nominal interest rate is $\left[(1 \% (\frac{1}{12})(0.10)) \& 1\right]$ = 0.008333 = 0.8333%
Interest charge = $\left[(\text{Actual cost})\,[1 \% (\frac{n}{12})(i)]^{n}\right]$- Actual cost

Item	Time of Use	Actual Cost	Months of Use	Nominal Interest Charge
Fertilizer	1-Feb	$24.45	10	$2.116
Cotton Seed	1- Apr	$17.28	8	$1.186
Insecticide	1-Jul	$20.000	5	$0.847
Insecticide	1-Aug	$20.000	4	$0.675
Insecticide	1-Sep	$20.000	3	$0.504
Total		$101.73		$5.328
Total Actual Cost + Interest		$107.058		

If the recommended method of calculating interest charges is used, then the implicit time value of money adjustments reflects the economic cost of financing the operation if all money is borrowed at the market rate of interest, and it is assumed that any revenues received at any time before the end of the period are invested at this same market rate of interest until the end of the period. Thus it may be useful to think of this time value adjustment as an implicit interest charge. In the real world, however, the producer may borrow only part of the money, the rate at which borrowing occurs may be different than the market rate of interest, and the rate at which revenues can be invested could be different than the rate at which funds are borrowed. A reasonable approach is to adjust all input costs (self- and externally financed) and any revenues to the end of the period using the time value formulas discussed with a specific interest rate. Explicit interest charges can be included for those items where interest is paid and implicit interest charges included as a time adjustment for unpaid (self-financed) interest. This unpaid interest would then not be considered in cash flow analyses. Alternatively, end-of-period prices could be used for all items that are not financed so that the implicit interest charge is contained in the price. This may be particularly useful in the case of owned equipment, buildings, or land, if an implicit cost of ownership is to be included. **Although there is some argument for using different rates of interest for the externally and internally financed items, a common practice is to use a weighted average rate for projected budgets. In any case, the assumptions used should be made explicit.**

The Task Force recommends that CAR estimates specify explicitly what rate of interest was used and to which items it was applied over what time period, so that estimates can easily be recomputed using alternative interest rate assumptions.

In preparing historical CAR estimates, there is less clear direction on appropriate procedures to account for explicit and implicit interest charges. One alternative is to use the actual interest paid to reflect the cost of borrowed funds and use the suggested adjustment procedures incorporating market interest rates to account for other implicit interest charges. A more theoretically pleasing alternative is to apply the same procedures to historical and projected budgets and treat actual financing as separate from estimation of CARs. This alternative, however, is open to criticism in that it ignores the actual situation and may be difficult to explain to farmers or policy makers.

The Task Force recommends that historical budgets explicitly state how all interest charges and time adjustments are applied so that alternative assumptions can be implemented easily.

Separating Within-Period Inflation and Real Interest Costs [3]

In periods of high inflation, such as the late 1970s and early 1980s in the United States and the 1990s in Eastern Europe and the former Soviet Union, it is useful to be able to separate out from nominal interest the costs that are due to inflation and those that are due to real interest. Costs associated with inflation are often compensated for by rising product prices in periods of high general inflation whereas real interest costs receive no such compensating adjustment. During periods of low and stable inflation such issues are of lesser concern. In order to adjust expenditures and revenues within a period and compute implicit interest charges it is necessary to adopt conventions for compounding and separating out the effects due to inflation and those due to implicit real interest. This is done correctly using the time adjustment techniques already discussed. Although such analysis is straightforward, building on previous discussion, the computations can become tedious; therefore, the exact procedures are discussed in Appendix 2A. The bottom line is that any nominal interest charge can be (somewhat arbitrarily) divided into real interest and inflation components.

Implicit and Explicit Interest Charges and Time Adjustments for Between-Period CARs

The costs of all inputs and the prices of all outputs in CAR estimation should be adjusted to the same point in time. Previous sections discussed how to adjust CAR flows within a given period. In the section entitled Real and Nominal Magnitudes, the **Task Force recommended that the nominal interest rate be used to adjust all within-year magnitudes to a common point in time and that point in time generally be the end of the production period or the end of the year, whichever is sooner.** This section discusses the adjustment of cash flows between periods. As discussed in connection with equation 2.10, real

[3]This section may be skipped if the reader is not interested in separating inflation and real interest costs.

and nominal discounted values will be the same if the base period for the real values is the period to which all flows are discounted.

> ***To ensure that real and nominal values are equivalent at the base time point, the Task Force recommends that the base point in time for the computation of all real values be the end of the current production period or the end of the current year, whichever is chosen as the base time point for CAR estimation.***
>
> ***Nominal CAR flows for periods other than the current one should be adjusted to the end of the current period using the appropriate interest rate. Real CAR flows for periods other than the current one should also be adjusted to the end of the current period using the appropriate interest rate.***

The use of this procedure guarantees that all CAR flows are valued in the same terms at the same point in time. Consider the following simple example of five cash flows expressed as nominal values on a time line. The first period begins at zero and ends at one.

-50.00	-200.00	60.00	102.00	312.12
-1	0	1	2	3

If the nominal interest rate is constant at 7.1% over this period, then the value of these cash flows at the end of period one using equation 2.4 is as follows:

$$
\begin{aligned}
V_1 &= \sum_{t=-1}^{3} \frac{R_t}{(1.071)^{t-1}} \\
&= \frac{-50}{(1.071)^{(-1-1)}} + \frac{-200}{(1.071)^{(0-1)}} + \frac{60}{(1.071)^{(1-1)}} + \frac{102}{(1.071)^{(2-1)}} + \frac{312.12}{(1.071)^{(3-1)}} \\
&= (-50)\,(1.071)^2 + (-200)(1.071) + 60 + \frac{102}{(1.071)} + \frac{312.12}{(1.071)^2} \\
&= -57.352 - 214.2 + 60 + 95.238 + 272.109 \\
&= 155.795\,.
\end{aligned}
$$

If the inflation rate during the entire time period from -1 to 3 was equal to 2%, then we can compute real values for each of these cash flows for any base period. If we assume that the base period is at point 1, then the value of 60 does not change. The value at point 0 of -200 is inflated to be -204 [(-200)(1.02)] in real terms. The value at point 3 of 312.12 is deflated to be 300 [$(312.12)(1.02)^{-2}$] at the base point. The time line in real values is then

-52.02	-204.00	60.00	100.000	300.00
-1	0	1	2	3

If the nominal interest rate is constant at 7.1% with a constant 2% rate of inflation, then the real interest rate is 5% for each period. With a 5% real rate of interest the value of these real cash flows at the end of period one is computed as

$$
\begin{aligned}
V_1^r &= \sum_{t=-1}^{3} \frac{R_t^r}{(1.05)^{t-1}} \\
&= \frac{-52.02}{(1.05)^{(-1-1)}} + \frac{-204}{(1.05)^{(0-1)}} + \frac{60}{(1.05)^{(1-1)}} + \frac{100}{(1.05)^{(2-1)}} + \frac{300}{(1.05)^{(3-1)}} \\
&= (-52.02)\,(1.05)^2 + (-204)(1.05) + 60 + \frac{100}{(1.05)} + \frac{300}{(1.05)^2} \\
&= -57.352 - 214.2 + 60 + 95.238 + 272.109 \\
&= 155.795.
\end{aligned}
$$

The value at the base point in time is the same as before.

Now consider a situation where the real interest rate is constant at 5% but inflation and nominal interest are as on the following time line, with the same nominal value flows as in the first case.

p		.01		.02		.02		0	
i		.0605		.071		.071		.05	
Value Flow	-50.00		-200.00		60.00		102.000		312.12
Time Point	-1		0		1		2		3

Thus the cash flow of -50 at point -1 would be adjusted from the point -1 to 0 at a nominal rate of 6.05% and from point 0 to point 1 at a rate of 7.1%. The value of this return stream at the end of period 1 must be computed using the individual nominal rates for each year as follows:

$$
\begin{aligned}
V_1 &\equiv (-50)\,(1.065)(1.71) + (-200)(1.071) + 60 + \frac{102}{(1.071)} + \frac{312.12}{(1.071)\,(1.05)} \\
&= -56.790 - 214.200 + 60 + 95.238 + 277.551 \\
&= 161.799\,.
\end{aligned}
$$

This is of course a different value than computed previously because the interest rates are different. But if we were to convert the nominal values in the example to real values using the latter stream of inflation rates and then discount them using the constant real interest rate of 5%, the value at end of period one would be the same. This can be verified by first computing the real values as follows:

$$
\begin{aligned}
V^r(-50) &= (-50)(1.01)(1.02) = -51.51 \\
V^r(-200) &= (-200)(1.02) = -204 \\
V^r(60) &= 60 \\
V^r(102) &= \frac{102}{1.02} = 100 \\
V^r(312.12) &= \frac{312.12}{(1)(1.02)} = 306.
\end{aligned}
$$

Discounting these real values with a 5% real rate as before will give

$$
\begin{aligned}
V_1 &= \sum_{t=-1}^{3} \frac{R_t}{(1.05)^{t-1}} \\
&= (-51.51)\,(1.05)^2 + (-204)(1.05) + 60 + \frac{100}{(1.05)} + \frac{306}{(1.05)^2} \\
&= -56.790 - 214.200 + 60 + 95.238 + 277.551 \\
&= 161.799.
\end{aligned}
$$

This gives the same value as the analysis using nominal values and nominal interest rates because both real and nominal value are discounted to the base period for defining real values.

The prediction of period-by-period inflation rates and asset price movements is not an easy task and is probably of second order concern in estimating production costs. Thus, rather than deal with nominal values and potentially different inflation and interest rates for each period of the analysis, it may be simpler to assume that all values outside of the current one are in real terms. This is especially true for projected estimates.

The Task Force recommends for projected estimates that all values outside of the period of analysis (current period in most cases) be denominated in real terms as of the end of the period of analysis. The Task Force also recommends that real interest rates be used for discounting flows between these outside periods. For historical estimates, the Task Force recommends the use of real values and real cash flows whenever feasible and straightforward to compute.

In summary, then, the preferred approach is to use nominal rates within the year and real rates between years.

> ***The Task Force recommends that CARs associated with production processes or assets lasting more than one year be calculated in nominal terms at the end of the production period and that nominal interest rates be used to discount such CARs within the given year. The Task Force suggests the end of the production period to be the base period for real values. The Task Force also suggests that CARs for years other than the production period (year) be computed on a real basis and that the real interest rate be used for discounting these returns between periods.***

Risk Premiums

When different income streams have different risk attributes, they will be evaluated differently by individuals. Similarly, in the market, investments having the same expected income but different risk characteristics will be priced differently. For example, the market price for farmland with an expected cash rental per acre per year of $120 may be different from the market price of a bond which guarantees $120 per year in perpetuity. And market rates of interest for income streams with risk properties similar to those in agriculture may be different from those for sectors of the economy that have different risk properties. Therefore, the general market rate of interest should not be used as the rate for most agricultural applications, but rather, a market rate adjusted for the risk inherent in agriculture should be used. This is not the rate of interest farmers pay for agricultural loans inasmuch as the commercial interest rate for agricultural loans may contain loan management fees and other distortions that reduce its value as a measure of the true discount rate. The preferred approach is to start with a risk-free market interest rate from the general economy and adjust it upwards for risk in agriculture. This topic along with a discussion of how to choose real and nominal interest rates for use in CAR estimation is discussed in the next section.

Choosing Rates of (Opportunity) Interest for CAR Estimation

An important issue in estimating CARs is choosing an appropriate opportunity cost of capital to use for discounting various income and cost flows. When nominal interest rates are high, the choice of a nominal rate and the associated inflation rate can have a significant impact on the magnitude of CARs. The rate that is appropriate for one type of analysis may not be the best rate to use for other purposes. For example, the rate to use in discussing peanut production in rural Georgia may not be appropriate for computing the average returns to Great Plains winter wheat. Furthermore, the rate to use for composite historical budgets may be different from the rate to use for a planning budget for an individual vegetable farmer. The key factor is to select a rate that reflects the actual market evaluation of alternatives to the cost, return, and risk associated with a given expenditure or revenue. There are two basic approaches to determining appropriate interest rates. The first is the so-called **bottom up** method, which starts from a risk-free real rate for the general economy, adds in a factor to account for riskiness of agricultural investments, and then another to account for inflation. Finally, the rate may be adjusted to account for transactions costs associated with investments. The second approach is the **top down** approach, which starts with the nominal interest rate charged on agricultural loans and attempts first to back out charges for transactions costs, and then adjust for inflation and riskiness to compare with non-risky real rates. Although the two approaches should give similar answers for the real and nominal rates to use in CAR estimation, there will be some differences due to a variety of errors in estimation. The biggest problem with using the agricultural loan rate in the top down approach is the difficulty in determining the portion of the rate due to transactions costs.

> ***The Task Force recommends that the bottom up approach of building from a risk-free general rate to a risky nominal rate for agriculture be used whenever feasible. This means starting from a risk-free rate for the general economy, adding a factor to account for riskiness of agricultural investments, and then another to account for inflation. Specifically, the Task Force recommends using the chained price index for the consumption component of GDP as the inflation factor.***

Determining the Risk-free Real Rate of Interest from a General Nominal Rate

The first step in the process is to obtain a risk-free real rate of interest as the basis for the other calculations. We think of a riskless asset as one with a nearly zero probability of default, and that is frequently traded at a negligible transactions cost, e.g., a Treasury bill (T-bill) or note. The risk-free rate of return will usually be different depending on the period of time the investment (asset) is to be held. A plot of the yield on government bonds with differing times to maturity but the same risk, liquidity, and tax considerations is called a **yield curve** (Mishkin, 1995: Chapter 7). The rate of return on a longer-term bond is related to the expected yield on shorter-term bonds because investors who have no inherent preference for one maturity over another will trade in equilibrium such that the expected rate of longer-term bonds will equal the average expected rate on shorter-term bonds that could be held. The yield curve generally slopes upwards because of the price risk associated with holding bonds for longer-term periods as opposed to holding shorter-term bonds and rolling them over. This liquidity premium associated with longer-term bonds premium leads to a higher risk-free rate for most long-term assets. For CAR estimation, if a particular expenditure commits capital for a long time period, the appropriate opportunity cost of that capital may be different than if the capital is only committed for a few months. For example, the rate for three-month T-bills might be used to proxy the riskless interest rate for money invested in producing vegetable crops and feeding enterprises, the rate for either six-month or one-year T-bills could be used for annual crops, and the rate for longer-term government bonds could be used for multiyear investments. It is most common, however, to choose a single rate for CAR estimation.

In the United States, the *ex ante* real short-term interest rate for a riskless asset (expressed in purchasing power over consumer goods) is usually approximated by the average nominal interest on a U.S. T-bill, adjusted by the expected rate of inflation. The *ex post* real interest rate on U.S. T-bills is the average annual nominal interest rate on these T-bills minus the actual rate of inflation. The actual rate of inflation is usually computed from some type of price index. For a one-year T-bill issued in January 1995 and redeemed in January 1996, the annual rate of inflation in 1995 is the appropriate adjustment factor. However, for a one-year T-bill issued in August 1995, the annual rate of inflation over the period August 1995-July 1996 is appropriate. Thus, there is some difficulty in using reported annual inflation rates to adjust annual average T-bill rates. One alternative is to always use the T-bill rate for the first month of the year. The more common method is to use the average annual rate on T-bills and simply use average calendar year inflation and assume the error from using the wrong period for the inflation adjustment is minimal. For projected budgets, the ex ante rate is most appropriate. Given the difficulties in forecasting inflation rates, however, a common practice for determining an expected real rate of interest is to average the ex post real rates for several years and use this as a forecast rather than use the Livingston index (Croushore, Bomberger and Frazer) or an econometrically estimated (Engle, Diba and Oh) expected rate of inflation. For example, in 1996 the average nominal interest rate on U.S. treasury securities at constant one-year maturity was 5.52% and the annual rate of inflation based on the price index for the consumption component of GDP was 2.2%. Using the Fisher equation (2.5) the implied **U.S. real rate of interest (return) on the "riskless" asset** (i.e., a one-year note) can be computed as 3.2485 % {([.0552 - .022]/1.022)(100)} for the year. If the interaction term in the Fisher equation rate is ignored, the ex post rate of return for the year was 3.32% {(.0552 − .022)(100)}.

Choosing Appropriate Nominal Rates of Interest from which to Construct a Risk-free Real Rate

The most commonly traded risk-free assets are various forms of U.S. government securities such as T-bills, notes, and bonds.

> ***The Task Force recommends that the nominal annual returns on U.S. government securities of various lengths be used as the basis for risk-free real rates and that the risk-free real rate be estimated as*** $r = \frac{(1+i)}{(1+p)} - 1$ ***where i is the nominal rate, r is the real rate, and p is the rate of inflation computed using the chained price index for the consumption component of GDP.***

The nominal rates of return on U.S. securities of various terms are given in Table 2.5. The change in the chained price index for all of GDP and its personal consumption component, as well as changes in the implicit price deflators for both series, are also reported. The change in the price index is probably the better measure to use for reflecting inflation. Ex post real rates of return on each security using the change in the personal consumption price index to adjust for inflation are also reported. Note that for T-bills the rate quoted is a discount rate that can be converted to a simple interest rate using the formula i = d/(1-d) (d is the discount rate expressed in hundredths) because T-bills are sold at a discount from face value and thus earn more than the discount rate. For example, a discount rate of 5% (.05) is equivalent to a 5.26% (.0526) simple interest rate. Notice that the real rate of return tends to be higher for assets with a longer maturity. For example, the average real return from 1987 through 1996 was 2.25% for three-month T-bills, 2.12% for one-year T-bills, and 4.03% for thirty-year Treasury notes. Estimates for the real rate of return on assets from current income in agriculture (a risky income stream) prepared by the ERS (USDA, Economic Indicators of the Farm Sector: National Financial Summary) are generally higher than the rate on ten-year notes and less than the rate on thirty-year notes. The rate of return in agriculture including capital gains is higher, averaging 4.05% over the period 1964-95. This risky nominal rate of return is also quite variable with a standard deviation above 5.

The data in Table 2.6 illustrate that although the derived real rates have fluctuated from year to year, the average over a period of years is relatively constant for each length of security other than during periods such as the 1970s when government policies resulted in negative real interest rates (Wilcox). If averages such as those in the top section of Table 2.6 are recomputed eliminating all years with negative real interest rates (1971-78), the results seem even more stable. Results obtained by eliminating the years 1971-78 from the multiyear averages are contained in the bottom section of Table 2.6. The years in the first column represent the first year of an average. For example, the fifteen-year average from 1982-1996 is reported in the 1982 row. Comparing the numbers for the averages ending in 1996, they range from 2.553 for the twenty-year average of the six-month rates to 4.7463 for the ten-year average of the thirty-year rates. Although recent work in monetary economics has indicated that the real rate may not be stationary over long periods (Mishkin 1981, 1992; Herndershott and Peek; Rose; Fried and Howitt; Gagnon and Unferth; Patel and Akella), there is still much debate on the subject. Garcia and Perron indicate that the ex post real rate was essentially random with means and variances that are different for the periods 1961-73, 1973-80, and 1980-86.

Given these studies, the most recent ten-year moving average of real interest rates computed from the comparable nominal rates is a good alternative. Based on the data in Tables 2.5 and 2.6, **a reasonable riskless real rate for U.S. investments in most crop and livestock inputs is in the range of 2.0% to 3.5%**. This riskless rate is also very consistent with long-held beliefs that the real interest rate is between 2% and 4% (Simon). The risk-free rate applicable to investments with long maturities may be higher due to the term premium.

Risk Differentials and Risky Discount Rates

The real (and nominal) interest rates or rates of return on all types of assets for any time period are generally different and not perfectly correlated. Thus, individuals, households, and businesses that are risk averse can reduce their income risk by diversifying their holding of assets. Among risky assets, competitive market forces cause equilibrium-compensating real rate of return differentials to emerge. Assets that have greater risk (e.g., corporate bonds, venture capital, shares of stock, or shares in a mutual fund) than a riskless asset usually have a higher real rate of return than the riskless asset. Among risky assets, competitive forces insure that, on average, the expected (and average actual) rate of return will be higher for more risky assets. Thus the expected return to investing in limited partnership office buildings may be larger than the expected return from investing in a “conservative” mutual fund based on the associated return patterns. But given the ability of diversification to reduce risk, the return premium demanded by an investor to commit funds to a particular asset depends not only on variability of returns associated with that asset, but also on how that asset contributes to the variability of the total investment portfolio.

An individual (producer or outside investor) considering an investment in agriculture must then consider the distribution of returns on the investment and their interaction with the other returns in the individual’s total asset portfolio. Returns to many agricultural enterprises and operations are quite variable due to weather, disease, incidence of pests, and market prices. Whether these variable returns increase the risk associated with the investor’s total portfolio depends on the composition of assets held. Many agricultural producers are not well diversified outside of agriculture and so bear considerable risk by holding assets and operating a farm business. On the other hand, many outside investors may add little risk to a well-diversified portfolio by adding agricultural investments. In considering the opportunity cost of funds invested in the farm business, one must then consider the type of asset portfolios to which the funds will be added. For a well-diversified portfolio, the premium above the risk-free rate that the investor expects may be low, but for a portfolio comprised primarily of other agricultural assets, the risk premium above the risk-free rate may be substantial.

The Capital Asset Pricing Model (CAPM) and Risk-Adjusted Discount Rates

The capital asset pricing model developed by Sharpe, Lintner, and Mossin is a market-based model that attempts to predict the equilibrium rate of return on an asset based on its contribution to a total market wealth portfolio. The model argues that individual capital assets are priced in equilibrium to reflect the asset's contribution to the risk of a well-diversified portfolio, and that risk premiums are paid only to an asset's owner for bearing the systematic, or market, risk that is pervasive in the universe of assets. Given its assumptions, the model implies that investors will be able to diversify away all risk of holding a particular asset except the covariance of that asset with the market portfolio. The model then implies that as the covariance between an asset's returns and market returns becomes larger, the asset's price is adjusted to provide higher rates of return. The empirical version of the model implies that the expected rate of return of an individual asset above the risk-free rate of return is a linear function of the excess of the expected rate of return of the "market" portfolio over the same risk-free rate. Let the random rate of return to asset j be given by $\tilde{R}_j$, the random rate of return to the market portfolio by $\tilde{R}_m$, and the risk-free rate of interest by R_f. Let a bar ($\bar{\ }$) above a rate of return denote the expected excess rate of return for either the asset or the market portfolio so that $\bar{R}_j = E(\tilde{R}_j) - R_f$ and $\bar{R}_m = E(\tilde{R}_m) - R_f$. Then we have as the empirical version of the CAPM $\bar{R}_j = \alpha_j + \beta_j \bar{R}_m$. The constant term ($\alpha_j$) is hypothesized to be zero, and the slope coefficient (beta) is equal to σ_{jm}/σ_m^2 where j indexes the j^{th} asset, m indexes the market portfolio, and σ_{jm} is the covariance between returns to asset j and the market portfolio. Estimates of the model parameters can be obtained using ordinary least squares by appending a serially uncorrelated zero mean normal random disturbance to the right-hand side of the equation. It is also assumed that the contemporaneous correlation across assets is stationary. Estimates of β then provide information of the relative riskiness of alternative assets with higher levels of β implying higher risk. While α_j is hypothesized to be zero, non-zero estimates can be used to compare the expected returns of a particular asset to those of assets with similar values for β. As a general alternative to CAPM, arbitrage pricing theory (APT) developed by Ross argues that the price of an asset depends linearly on k factors rather than the single factor represented by the rate of return on the market portfolio. These factors are common to the returns of all assets under consideration. The CAPM and APT models can be used to determine how an investment in a particular stock, type of real estate, or other asset contributes to the performance of a well-diversified market portfolio. They can also be used to determine if the observed rate of return on a particular investment is similar to returns with the same level of risk.

Empirical Evidence on Riskiness of Asset Returns in Agriculture

Several authors (Barry; Irwin et al.; Bjornson and Innes; Bjornson) have applied CAPM and APT models to agricultural assets. The purpose of these studies was to determine whether or not investments in agriculture can help diversify away risk for holders of the market portfolio, and to compare the agricultural returns to nonagricultural returns with similar riskiness. Both Barry and Irwin et al. find that there is little, if any, risk premium for holding agricultural assets using CAPM and an inflation-adjusted CAPM. They also find that risk-adjusted returns to agricultural assets are slightly higher (the constant term [a_j] is positive in the regression) than expected under CAPM. Irwin et al. also suggest that these returns are sensitive to inflation. Bjornson and Innes attempt to obtain separate effects for landlords and owner-operators using both CAPM and APT. They find similar CAPM results for landlords but different results for owner-operators. They find a positive ß for owner-operators but a negative a, implying less than expected risk-adjusted returns for this group. Using a cross section regression, they find that returns to agricultural owner-operators are significantly lower than returns to owners of nonagricultural assets with the same level of systematic risk. They find that returns on farmland ownership are higher than on nonagricultural assets, but only statistically so at the 20% level. Their APT model implies that returns to both landlords and owner-operators are sensitive to some systematic (market) risk. Land, in particular, may be a hedge against unexpected inflation. Again, the returns to land ownership seem to be higher than for similar risk nonagricultural assets, but the returns to owner-operators seem to be lower. The required returns to landholders may be larger than on the market portfolio due to the illiquid nature of land or to the fact that many land owners may have poorly diversified investments. The lower rate accepted by owner-operators may be due to psychic benefits from farming (Brewster). **Based on these results, it is not clear that the risky rate of return for all of agriculture is any higher than for comparable risk nonagricultural assets (of similar ß), and it may be slightly lower.**

Adjusting the Risk-free Real Interest Rate for Use in Agricultural CAR Analysis

Given a well-specified CAPM for returns to agricultural assets in which a is close to zero, an estimate of the excess rate of return to be used for discounting can be obtained by multiplying the market excess rate of return by the estimated ß. If a is significantly different from zero and one believes that this is a structural phenomenon common to assets in agriculture, the predicted value from the CAPM model using both a and ß coefficients could be used. If a is positive, this implies that investments in agriculture yield a higher rate of risk-adjusted excess return than the market portfolio. This could possibly be due to limited portfolio diversification by individuals typically investing in agriculture. When a is negative, however, this implies that the agricultural producer is accepting a rate of return less than that possible from choosing a well-diversified portfolio of similar ß risk.

A simple, but inexact, alternative for CAR estimation may be to consider the real market rate of return as a ballpark estimate of the risk-adjusted rate of return for agriculture with the idea that the well-diversified investor should be able to get at least this rate of return with normal risk. Given the relatively low ß's typically estimated for agricultural assets (or higher ß's with negative a's) and the opportunity for most agricultural investors to diversify if they so choose, it may be appropriate to view the market rate of excess returns as an upper bound on this risk adjustment. **Therefore, an estimate of the upper bound for the risky real discount rate for agricultural cash flows (or "assets") can be obtained by simply adding estimates of the market excess rate of return to the chosen real risk-free interest rate**.

A crude estimate of the risk premium for a specific type of agricultural production where person receiving the returns is not diversified outside this investment could be calculated using a series of annual returns on assets used for the particular type of production and region of interest. The series of returns on agricultural assets should be expressed in real terms. A nominal series could be deflated by the change in a price index to obtain a real series. The average difference over a series of production periods between this real return on agricultural assets and the real return on government securities is a crude estimate of the risk premium. This relatively simple approach could be used to estimate the risk premium for various sizes and types of agricultural production when the required data are available. But because investors in agricultural production have access to the general capital markets, the excess returns associated with these markets are probably more relevant.

Estimates of the Market Excess Rate of Return

In their paper investigating returns in agriculture, Bjornson and Innes estimate a mean excess return for their constructed “market portfolio” over the years 1963-84 of 3.2%. Fama and French, in a paper on common risk factors in returns to stocks and bonds, find an average excess monthly return of 0.43% for their market portfolio over the period 1963-1990. This is equivalent to a 5.28% [1.0043^{12} -1] annual excess rate of return. They report an excess return for AAA-rated corporate bonds of 0.06% per month with an excess return on BAA-rated bonds of 0.14% per month. The annual equivalents to these monthly rates are 0.70% and 1.69%. Carhart, in a paper on persistence in mutual fund performance, uses a value-weighted stock index prepared by the Center for Research in Security Prices (CRSP) minus the one-month T-bill return as the market excess rate of return. This averages 0.44% over the period July 1963-December 1993. This translates into a 5.41% [1.0044^{12} -1] annual rate. Data on historical returns on stocks, bonds, and bills prepared in 1997 by Ibbotson Associates indicate annual real rates of returns on large company (S&P 500) stocks above the risk-free interest rate of 4.14% for the period 1964-96, 5.88% for the period 1982-96, and 7.41% during the recent high return period of 1987-96. Rates on a set of small company stocks averaged 9.78%, 9.38%, and 4.55% for the same periods. **Based on these studies and others, a reasonable estimate of an additive risk adjustment for agricultural investments would be from 3 to 6%**.

Suggested Risky Real Discount Rates for Agriculture

Given a long-term real rate of 2.0 to 3.5%, and an additive risk adjustment in agriculture from 3 to 6%, the long-term risky real rate for investments in agriculture probably ranges from 5.0 to 9%. This is significantly higher than the average rate of return on assets from current income for all of U.S. agriculture of 3.29% as reported in Table 2.5 for the years 1964-95. It is also higher than the rate of return on assets including capital gains which averaged 5.4% over the same period. Thus, the opportunity costs of funds invested in agriculture operations may tend to be higher than their own rate of return if the capital gains do not accrue to the investor.

Operating a farm business is a risky venture. Returns in any one year are highly variable due to weather, biological catastrophe, labor problems, and prices. The probability of economic failure during any time period is larger than zero. For individual farms, especially those that are in "poor" financial condition, this risk may be substantial. Institutions loaning money to agricultural enterprises may demand a premium because of the probability of default, particularly if the lender is not well diversified. Thus the price charged for agricultural loans may be higher than for loans in some other sectors of the economy. But this loan risk premium is not directly relevant for analyzing the opportunity cost of funds invested in agriculture. The opportunity cost for agricultural funds should be based on alternative investments in the rest of the economy. If there is some desire to account for this cost of loanable funds, some type of weighted cost of capital might be used instead of the opportunity cost (Levy and Sarnat 1994: Chapter 17). This approach, however, is not generally recommended for risky investments by practitioners in capital budgeting (Bierman and Smidt: 397).

TABLE 2.5 Nominal and Ex Post Real Interest Rates 1964-1996 (Averages begin in year noted)

Year	3-month T-bill	6-month T-bill	1-year T-bill	1-year Note	3-year Note	5-year Note	10-year Note	30-year Note	? GDP Price‡ Index	? GDP Deflator	? PCE† Price‡ Index	? PCE Deflator	3-month T-bill (Real)§	6-month T-bill (Real)	1-year T-bill (Real)	1-year Note (Real)	3-year Note (Real)	5-year Note (Real)	10-year Note (Real)	30- Note (Real)	ROR¶ Assets U.S. Ag.
1964	3.56	3.69	3.75	3.85	4.03	4.07	4.19		1.5	1.5	1.4	1.4	2.030	2.258	2.318	2.416	2.594	2.633	2.751		2.52
1965	3.95	4.05	4.06	4.15	4.22	4.25	4.28		1.9	2	1.6	1.6	2.012	2.411	2.421	2.510	2.579	2.608	2.608		3.54
1966	4.88	5.08	5.07	5.2	5.23	5.11	4.93		2.8	2.8	2.6	2.6	2.023	2.417	2.407	2.534	2.563	2.446	2.446		3.82
1967	4.32	4.63	4.7	4.88	5.03	5.1	5.07		3.2	3.2	2.7	2.7	1.085	1.879	1.947	2.123	2.269	2.337	2.337		2.9
1968	5.34	5.47	5.46	5.69	5.68	5.7	5.64		4.4	4.4	4	4	0.900	1.413	1.404	1.625	1.615	1.635	1.635		2.65
1969	6.68	6.85	6.79	7.12	7.02	6.93	6.67		4.7	4.7	4.1	4.1	1.891	2.642	2.584	2.901	2.805	2.719	2.719		3.21
1970	6.43	6.53	6.49	6.9	7.29	7.38	7.35		5.3	5.3	4.7	4.7	1.073	1.748	1.710	2.101	2.474	2.560	2.560		3.09
1971	4.35	4.51	4.67	4.89	5.66	5.99	6.16		5.2	5.2	4.5	4.5	-0.808	0.010	0.163	0.373	1.110	1.426	1.426		3.15
1972	4.07	4.47	4.76	4.95	5.72	5.98	6.21		4.2	4.2	3.5	3.5	-0.125	0.937	1.217	1.401	2.145	2.396	2.396		4.33
1973	7.04	7.18	7.02	7.32	6.96	6.87	6.85		5.6	5.6	5.4	5.4	1.364	1.689	1.537	1.822	1.480	1.395	1.395		7.82
1974	7.89	7.93	7.72	8.2	7.84	7.82	7.56		8.9	9	10.1	10.1	-0.927	-1.971	-2.162	-1.726	-2.053	-2.071	-2.307		4.68
1975	5.84	6.12	6.3	6.78	7.5	7.78	7.99		9.4	9.4	8.1	8.1	-3.254	-1.832	-1.665	-1.221	-0.555	-0.296	-0.102		3.73
1976	4.99	5.27	5.52	5.88	6.77	7.18	7.61		5.8	5.8	5.7	5.7	-0.766	-0.407	-0.170	0.170	1.012	1.400	1.400		2.2
1977	5.27	5.52	5.7	6.08	6.68	6.99	7.42	7.75	6.5	6.5	6.6	6.6	-1.155	-1.013	-0.844	-0.488	0.075	0.366	0.769	1.079	1.88
1978	7.22	7.58	7.74	8.34	8.29	8.32	8.41	8.49	7.3	7.3	7.3	7.3	-0.075	0.261	0.410	0.969	0.923	0.951	1.034	1.109	2.46
1979	10.05	10.02	9.73	10.7	9.7	9.51	9.43	9.28	8.5	8.5	9	9	1.429	0.933	0.670	1.514	0.642	0.468	0.394	0.257	2.64
1980	11.51	11.37	10.9	12	11.5	11.5	11.43	11.27	9.3	9.2	10.9	10.9	2.022	0.427	-0.045	0.992	0.550	0.496	0.478	0.334	1.28
1981	14.03	13.78	13.2	14.8	14.5	14.3	13.92	13.45	9.4	9.4	8.9	8.9	4.232	4.478	3.912	5.418	5.106	4.913	4.610	4.178	2.36
1982	10.69	11.08	11.1	12.3	12.9	13	13.01	12.76	6.3	6.3	5.8	5.8	4.130	4.994	4.981	6.115	6.739	6.815	6.815	6.578	2.29
1983	8.63	8.75	8.8	9.58	10.5	10.8	11.1	11.18	4.3	4.3	4.5	4.6	4.151	4.067	4.115	4.861	5.694	6.019	6.316	6.392	1.41
1984	9.35	9.77	9.94	10.9	11.9	12.3	12.46	12.41	3.8	3.8	3.8	3.8	5.347	5.751	5.915	6.850	7.823	8.150	8.343	8.295	3.34
1985	7.47	7.64	7.81	8.42	9.64	10.1	10.62	10.79	3.4	3.4	3.7	3.7	3.936	3.799	3.963	4.552	5.728	6.191	6.673	6.837	3.81
1986	5.98	6.03	6.07	6.45	7.06	7.3	7.67	7.78	2.6	2.6	2.8	2.8	3.294	3.142	3.181	3.551	4.144	4.377	4.737	4.844	3.34
1987	5.82	6.05	6.33	6.77	7.68	7.94	8.39	8.59	3.1	3.1	3.8	3.8	2.638	2.168	2.437	2.861	3.738	3.988	4.422	4.615	4.33
1988	6.69	6.92	7.13	7.65	8.26	8.48	8.85	8.96	3.7	3.7	4.2	4.1	2.883	2.610	2.812	3.311	3.896	4.107	4.463	4.568	4.02
1989	8.12	8.04	7.92	8.53	8.55	8.5	8.49	8.45	4.2	4.2	4.9	4.9	3.762	2.993	2.879	3.460	3.480	3.432	3.422	3.384	4.64
1990	7.51	7.47	7.35	7.89	8.26	8.37	8.55	8.61	4.4	4.3	5.1	5.1	2.979	2.255	2.141	2.655	3.007	3.111	3.283	3.340	4.29
1991	5.42	5.49	5.52	5.86	6.82	7.37	7.86	8.14	3.9	4	4.2	4.2	1.463	1.238	1.267	1.593	2.514	3.042	3.512	3.781	3.07
1992	3.45	3.57	3.71	3.89	5.3	6.19	7.01	7.67	2.8	2.8	3.3	3.3	0.632	0.261	0.397	0.571	1.936	2.798	3.591	4.230	4.12
1993	3.02	3.14	3.29	3.43	4.44	5.14	5.87	6.59	2.6	2.6	2.6	2.6	0.409	0.526	0.673	0.809	1.793	2.476	3.187	3.889	3.05
1994	4.29	4.66	5.02	5.32	6.27	6.69	7.09	7.37	2.3	2.3	2.4	2.4	1.945	2.207	2.559	2.852	3.779	4.189	4.580	4.854	3.69
1995	5.51	5.59	5.6	5.94	6.25	6.38	6.57	6.88	2.5	2.5	2.4	2.4	2.937	3.115	3.125	3.457	3.760	3.887	4.072	4.375	1.73
1996	5.02	5.09	5.22	5.52	5.99	6.18	6.44	6.71	2.1	2	2.2	2.1	2.860	3.029	2.955	3.350	3.043	3.058	3.385	3.251	
High	14.03	13.78	13.2	14.8	14.5	14.3	13.92	13.45	9.4	9.4	10.9	10.9	5.347	5.751	5.915	6.850	7.823	8.150	8.343	7.820	7.820
Low	3.02	3.14	3.29	3.43	4.03	4.07	4.19	6.59	1.5	1.5	1.4	1.4	-3.254	-1.971	-2.162	-1.726	-2.053	-2.071	-2.307	1.280	1.280
Ave	6.497	6.647	6.67	7.15	7.56	7.74	7.912	9.157	4.724	4.72	4.75	4.75	1.707	1.831	1.855	2.312	2.679	2.849	3.011	3.293	3.293
STD	2.474	2.415	2.27	2.61	2.46	2.41	2.37	2.036	2.295	2.29	2.4	2.4	1.856	1.784	1.770	1.908	2.033	2.072	2.153	1.213	1.213

Source: Federal Reserve Bulletin (Board of Governors), Survey of Current Business (Department of Commerce), Economic Report of the President (U.S. Government Printing Office), various issues, unpublished data available from the Federal Reserve Board and the Department of Commerce.

† Change in Personal Consumption Component of GDP, ‡ Change in chained price index for series, § Real rates computed using nominal rates and the change in the chained price index for the consumption component of GDP ¶ Real rate of return on current assets in agriculture as computed by ERS # Standard Deviation.

TABLE 2.6 Multiple Year Averages of Ex Post Real Interest Rates 1964-1996 for Years Starting in 1964-1987

Starting Year	3-T-bill 10 yr	3-T-bill 15 yr	3-T-bill 20 yr	3-T-bill 25 yr	6-month T-bill 10 yr	6-T-bill 20 yr	1-year Note 10 yr	1-year Note 15 yr	1-year Note 20 yr	1-year Note 25 yr	3-year Note 10 yr	3-year Note 20 yr	5-year Note 10 yr	5-year Note 15 yr	5-year Note 20 yr	10-year Note 10 yr	10-year Note 15 yr	10-year Note 20 yr	30-year Note 10 yr	30-year Note 15 yr
1964	1.1445	0.3513	1.0616	1.5733	1.7405	1.3671	1.980	1.167	1.820	2.3014	2.1634	1.9883	2.2154	1.5003	2.0607	2.2273	1.5378	2.084		
1965	0.8488	0.3112	1.2275	1.6426	1.3175	1.5418	1.566	1.107	2.042	2.3432	1.6987	2.2498	1.745	1.3559	2.3366	1.7214	1.3807	2.3636		
1966	0.3223	0.3119	1.3237	1.6813	0.8932	1.6112	1.193	1.006	2.144	2.349	1.3854	2.4073	1.4546	1.2151	2.5157	1.4504	1.2387	2.5668		
1967	0.0434	0.4591	1.3873	1.6588	0.6108	1.6474	0.956	1.198	2.195	2.3113	1.2302	2.4863	1.35	1.3795	2.6123	1.3458	1.3829	2.6814		
1968	-0.181	0.6621	1.4649	1.6407	0.3216	1.6618	0.695	1.464	2.232	2.2493	1.0109	2.5597	1.1529	1.678	2.6948	1.189	1.6814	2.7856		
1969	-0.278	0.8788	1.5641	1.6211	0.2064	1.7217	0.630	1.680	2.316	2.2166	0.9416	2.6738	1.0845	1.9703	2.8185	1.129	1.9935	2.927		
1970	-0.324	1.1092	1.6576	1.6232	0.0355	1.7393	0.491	1.943	2.344	2.2146	0.7253	2.7075	0.8594	2.3325	2.8542	0.8966	2.3685	2.9622		
1971	-0.23	1.3001	1.7529	1.6978	-0.097	1.7646	0.380	2.106	2.372	2.2689	0.533	2.7342	0.653	2.5745	2.8817	0.6884	2.6427	2.9984		
1972	0.2745	1.5736	1.8664	1.8445	0.3502	1.826	0.885	2.318	2.433	2.3879	0.9325	2.8044	1.0017	2.7713	2.9626	1.0068	2.8635	3.1027		
1973	0.7	1.7578	1.9043		0.756	1.7923	1.356	2.416	2.391		1.3919	2.7939	1.4436	2.8775	2.9826	1.4487	2.9985	3.1625		
1974	0.9787	1.8591	1.8566		0.9938	1.7341	1.660	2.515	2.340		1.8133	2.8096	1.906	3.0583	3.0367	1.9408	3.2031	3.2521		
1975	1.6062	2.1717	2.0002		1.766	1.943	2.518	2.861	2.569		2.8008	3.1012	2.9281	3.4252	3.3497	3.0058	3.585	3.5964		
1976	2.3252	2.5872	2.3098		2.3291	2.1904	3.095	3.119	2.803		3.4292	3.3169	3.5768	3.6523	3.5588	3.6833	3.8106	3.8051		
1977	2.7312	2.7358	2.491		2.684	2.3622	3.433	3.214	2.962		3.7423	3.4185	3.8746	3.7618	3.6417	4.017	3.9514	3.9044	3.9903	3.9728
1978	3.1105	2.855			3.0021		3.768	3.284			4.1086		4.2368	3.9239		4.3823	4.1396		4.3439	4.1829
1979	3.4063	2.8872			3.237		4.002	3.274			4.406		4.5525	4.0256		4.7251	4.2831		4.6898	4.3682
1980	3.6396	2.9217			3.443		4.197	3.363			4.6897		4.8489	4.2737		5.0278	4.5621		5.0026	4.6746
1981	3.7353	2.9826			3.6258		4.363	3.527			4.9354		5.1104	4.4997		5.3083	4.8018		5.3032	4.9441
1982	3.4584	2.8912			3.3019		3.980	3.389			4.6763		4.9234	4.3761		5.1986	4.7201		5.2635	4.8823
1983	3.1087				2.8286		3.426				4.196		4.5217			4.8763			5.0287	
1984	2.7344				2.4745		3.021				3.8059		4.1673			4.5634			4.7783	
1985	2.3943				2.12		2.621				3.4016		3.7712			4.1871			4.4342	
1986	2.2943				2.0516		2.512				3.2047		3.5408			3.927			4.188	
1987	2.2509				2.0404		2.491				3.0946		3.4089			3.7918			4.0287	
Ave	1.6706	1.7161	1.7049	1.6648	1.7514	1.7788	2.301	2.366	2.354	2.2936	2.6799	2.718	2.847	2.8764	2.879	2.9891	3.0076	3.0137	4.641	4.5041
High	3.7353	2.9826	2.491	1.8445	3.6258	2.3622	4.363	3.527	2.962	2.3879	4.9354	3.4185	5.1104	4.4997	3.6417	5.3083	4.8018	3.9044	5.3032	4.9441
Low	-0.324	0.3112	1.0616	1.5733	-0.097	1.3671	0.380	1.006	1.820	2.2146	0.533	1.9883	0.653	1.2151	2.0607	0.6884	1.2387	2.084	3.9903	3.9728

TABLE 2.6 (continued)

---------- Data truncated to eliminate the years 1971-1978 ----------

Starting Year	3-month T-bill 10 yr	3- T-bill 15 yr	3-month T-bill 20 yr	6- T-bill 10 yr	6- T-bill 20 yr	1-year Note 10 yr	1-year Note 15 yr	1-year Note 20 yr	3-year Note 10 yr	3-year Note 20 yr	5-year Note 10 yr	5-year Note 15 yr	5-year Note 20 yr	10-year Note 10 yr	10-year Note 15 yr	10-year Note 20 yr	30-year Note 10 yr	30-year Note 15 yr
1964	1.8697	2.6371	2.6641	2.0607	2.6813	2.4134	3.3375	3.1971	2.3196	3.4980	2.2814	3.6244	3.6024	2.2538	3.6948	3.7262		
1965	2.0798	2.6776	2.5942	2.3343	2.5814	2.7833	3.3671	3.1049	2.7342	3.4651	2.6996	3.7148	3.6106	2.6601	3.8062	3.7682		
1966	2.2937	2.7357	2.5141	2.4999	2.4872	3.0184	3.4205	3.0198	3.0457	3.4258	3.0407	3.8147	3.6040	3.0309	3.9298	3.7971		
1967	2.6261	2.8517	2.5102	2.8333	2.4767	3.4500	3.4823	3.0357	3.5716	3.4866	3.6111	3.8804	3.6911	3.6205	3.9948	3.9038		
1968	2.9112	2.9779	2.6027	3.0253	2.5385	3.6929	3.5178	3.1024	3.9176	3.5612	3.9965	3.9321	3.7686	4.0542	4.0579	3.9906		
1969	3.1506	3.0154	2.7007	3.1982	2.6193	3.8854	3.5156	3.1886	4.1704	3.6325	4.2707	4.0259	3.8398	4.3644	4.1831	4.0781		
1970	3.2253	2.9315		3.1508		3.8814	3.3603		4.2637		4.3977	4.0312		4.5348	4.2413			
1979	3.4063	2.8872		3.2370		4.0024	3.2742		4.4060		4.5525	4.0256		4.7251	4.2831		4.6898	4.3682
1980	3.6396	2.9217		3.4430		4.1971	3.3633		4.6897		4.8489	4.2737		5.0278	4.5621		5.0026	4.6746
1981	3.7353	2.9826		3.6258		4.3634	3.5277		4.9354		5.1104	4.4997		5.3083	4.8018		5.3032	4.9441
1982	3.4584	2.8912		3.3019		3.9809	3.3898		4.6763		4.9234	4.3761		5.1986	4.7201		5.2635	4.8823
1983	3.1087			2.8286		3.4265			4.1960		4.5217			4.8763			5.0287	
1984	2.7344			2.4745		3.0212			3.8059		4.1673			4.5634			4.7783	
1985	2.3943			2.1200		2.6214			3.4016		3.7712			4.1871			4.4342	
1986	2.2943			2.0516		2.5120			3.2047		3.5408			3.9270			4.1880	
1987	2.2509			2.0404		2.4919			3.0946		3.4089			3.7918			4.0287	
Ave	2.8237	2.8645	2.5771	2.7641	**2.5530**	3.3588	3.4142	3.0920	3.7771	3.4873	3.9464	4.0181	3.6554	4.1328	4.2068	3.8372	**4.7463**	4.7173
High	3.7353	3.0154	2.6641	3.6258	2.6813	4.3634	3.5277	3.1971	4.9354	3.5612	5.1104	4.4997	3.7686	5.3083	4.8018	3.9906	5.3032	4.9441
Low	1.8697	2.6371	2.5102	2.0404	2.4767	2.4134	3.2742	3.0198	2.3196	3.4258	2.2814	3.6244	3.6024	2.2538	3.6948	3.7262	4.0287	4.3682

Sources: Federal Reserve Bulletin, Survey of Current Business, Economic Report of the President, various issues, unpublished data available from the Federal Reserve Board and the Department of Commerce.

† Change in personal consumption component of GDP, ‡ Change in chained price index for series.

The literature on capital budgeting under uncertainty (Bogue and Roll; Fama; Constantinides; Copeland and Weston: Chapter 12; Robison and Barry (1996): Chapter 23; Lee: Chapter 10) argues that risk-free interest rates used for discounting cash flows should be adjusted to account for the riskiness of the various flows, or that the flows should be adjusted to a certainty equivalent basis. There are a number of theoretical problems in doing this for long time horizons (Fama), but general practice in portfolio management and capital budgeting has been to use a constant risk-adjusted discount rate as estimated using an asset pricing model, and proceed as if this were the relevant and correct rate for each item. Although not specifically endorsing this approach, this Task Force feels this is a reasonable alternative for applied work.

Adjusting the Risky Real Discount Rate to Account for Inflation

The risky real discount rate can be adjusted upwards for inflation using the chained price index for the consumption component of the GDP and the Fisher equation. For example, if the real rate is 2.0% and the risk adjustment is 3.0% with 4% inflation, the implied risky nominal rate is

$$i = (.020 + .030) + .04 + (.05)(.04) = .092 = 9.2\%.$$

More precise adjustments, allowing for risk to affect the nominal rate directly, can also be considered if inflation is sufficiently high. Although the Task Force does not recommend specific real and nominal rates of return, it does recommend appropriate procedures.

The Task Force recommends:

(1) Adjusting the nominal rate of return for a class of government securities by the chained price index for the consumption component of GDP to obtain a risk-free real rate of discount for a class of agricultural assets with like maturity. This adjustment should use the Fisher equation (2.5).

(2) Adjusting the estimated risk-free real rate to account for risk in agriculture by either:

> ***(a) Using an asset pricing model to relate the excess rate of return on agricultural assets to the market excess rate of return, or***
>
> ***(b) Adding the market excess rate of return to the estimated risk-free real rate of return.***

(3) Adjusting the estimated risky real rate to account for inflation using the chained price index for the consumption component of GDP. This adjustment should use the Fisher equation (2.5).

VALUING THE SERVICES OF OWNED CAPITAL

Introduction and Example

The most controversial and complex cost calculations are those associated with the service flows from capital assets owned by the producer. As discussed in the section entitled Valuing Factors for which there is no Market Transaction, ***the Task Force recommends that market-determined costs of inputs should be used when they are available***. A market-based definition for the costs of capital services is as follows:

> The **cost (or revenue to owner) of capital services** for a given period is the market price the owner of the capital resource is able to obtain for these services. This is the cost that should be included in CAR estimates.

If there is a market transaction for the capital service, the associated price should be used to compute the service flow cost. When the operator of the firm owns the capital good and a market price cannot be obtained to value the service flow, it can be proxied by the returns that should accrue to that asset in economic equilibrium. This is done by assuming that the capital service will be offered for no less than the full costs of providing that service in an arm's-length market transaction. This can be done using data on similar market transactions (market prices for similar products or services, custom rates, etc.) or through determining the costs of providing the service. The discussion on determining these costs will build on simple examples and elementary concepts. The simplest ownership situation to consider is when the owner of the asset purchases it for use at the beginning of the period, obtains services from the asset which may reduce its service capacity, performs some maintenance and/or service enhancement during the period, incurs some other ownership costs, and then sells the asset at the end of the period. The asset may or may not have the same value at the end of the period as at the beginning depending on prices and use. Maintenance is usually considered an expendable cost that is necessary to maintain the basic service potential of an asset and extract its services; service enhancement costs are those associated with actions that significantly change the service potential. Lubrication is an example of maintenance and remodeling a packing shed would be considered service enhancement. We might say then that the costs of providing the services of the capital asset are as follows:

Capital service cost (CSC) ' *Opportunity cost of holding the asset*
% *service capacity reduction cost*
% *change in the price of the capital asset*s service capacity*
% *service enhancement cost*
% *maintenance cost*
% *other time costs.*

More careful discussion of the definition and the various concepts contained in it will be given after discussing an intuitive first example. If the owner buys the asset and then sells it at the end of the period, all costs are directly observable. The asset has a known fixed service life at the beginning of the period and this can be valued using the beginning-of-period market prices. The costs associated with maintenance and service enhancement are observed. Given the use, maintenance, and service enhancement that take place, the asset will have a different service life at the end of the period. This new service life also has a market value at end-of-period prices. If the end of the period is the period for which all costs are computed, then beginning and within period expenses can be inflated to the end of the period using the nominal rate of interest. A specific example will be used to illustrate this and other cases.

Suppose there is a tractor with 1,500 hours of useful life at the beginning of the year. The rental price of an hour of tractor time at the beginning of the period is $20. The tractor has beginning-of-period market value of $30,000. Assume that during the year the owner has maintenance costs of $200 for lubrication and minor repairs. At the end of the year the tractor has a useful life of 1,250 hours, either because it was used for 250 hours, or time and use together reduced its useful life by 250 hours. The price of an hour of tractor time at the end of the period is $21. Thus the market value at the end of the period is $26,250. Also assume that the owner performs service enhancement (new hydraulics) at the end of the year that increases the useful life to 1,300 hours. This service enhancement costs $1,050 in end-of-year dollars. With this service enhancement the tractor is now worth $27,300 [(1,300)(21)] at year's end. Assume the real interest rate is 4% and the rate of inflation is 5%. These two rates imply an implicit annual nominal interest rate of 9.2% {(.04+.05+(.04)(.05))(100)} using the Fisher equation. The implied nominal rate for a month is .7361% and the implied real rate for a month is .3274%. The data for this tractor are given in Table 2.7.

TABLE 2.7 Cost Data on Purchase and Sale of Tractor

Real interest rate	.04=4%
Inflation rate	.05=5%
Implied nominal interest rate	.092=9.2%

	Quantity (hours)	Price ($)	Total ($)
Beginning of period useful life	1,500	20	30,000
Midperiod maintenance			200
End-of-period service enhancement			1,050
End-of-period useful life before enhancement	1,250	21	26,250
End-of-period useful life after enhancement	1,300	21	27,300

The cost for the year is found by computing all explicit and implicit costs, and then adjusting them to an end-of-period value. There are a number of ways to do this calculation, each of which gives the same results but slightly different insights. Consider first simply adjusting all values to the end of the period and then comparing costs with revenues. The first cost is the purchase for $30,000. Adjusted to year end by the nominal interest rate, this gives a cost of $32,760. Assume that the maintenance all takes place at midyear (six months) for ease of computation. Also assume that the $200 is a nominal value as of the middle of the year. Then the adjusted maintenance cost is given by multiplying the actual maintenance cost by $(1+i)^{.5}$ which gives $(200)(1.092)^{.5}$ = $208.99. Prior to any service enhancement the tractor has a year-end value of $26,250. The total cost of using the tractor can be obtained by adding the adjusted purchase cost and the adjusted maintenance cost and then subtracting the sale price of the tractor. Table 2.8 gives the data in tabular form.

TABLE 2.8 Cost of Using a Tractor Assuming Purchase and Sale Ignoring Service Enhancement (in $)

Item	Actual Cost/Return	End-of-Period Cost/Return
Purchase	30,000.00	32,760.00
Maintenance	200.00	208.99
Sale	-26,250.00	-26,250.00
Total cost in end-of-period $		6,718.99

An alternative approach is to include the cost of service enhancement, but also increase the projected sale price of the tractor to reflect this increased value. The service enhancement takes place at the end of the year and so need not be adjusted in value for time. At the end of the year, after service enhancement, the tractor has a useful life of 1,300 hours, which has a value of $27,300 [(1,300)(21)]. In tabular form this approach gives the data in Table 2.9.

TABLE 2.9 Cost of Using a Tractor Assuming Purchase and Sale Incorporating Service Enhancement (in $)

Item	Actual Cost/Return	End-of-Period Cost/Return
Purchase	30,000.00	32,760.00
Maintenance	200.00	208.99
Service Enhancement	1,050.00	1,050.00
Sale	-27,300.00	-27,300.00
Total cost in end-of-period $		6,718.99

The total cost of using the tractor can be obtained by adding the adjusted purchase cost, the adjusted maintenance cost, and the service enhancement cost, and then subtracting the sale price of the tractor. The total cost of $6,718.99 is the same as before. If maintenance is considered an expendable cost item, the cost of ownership and use is just $6,510.

The above example illustrates how to compute the costs of purchasing an asset, holding it for one period, and then liquidating it. In most situations an asset owner will not buy and sell an asset each period and so an alternative approach is needed. The suggested approach is based on the idea that the costs obtained should be the same as if the asset owner bought and sold the asset each period assuming efficient markets and no transactions costs. It is possible to divide these costs as follows: components associated with the opportunity cost of holding financial wealth in the tractor, the real interest and inflation components of that cost, the costs associated with the tractor losing service capacity over the period, and the costs (revenues) associated with changes in the value of service capacity of the tractor due to price changes. Although such division is not necessary if the tractor is purchased and sold, it is essential in imputing costs if the tractor is held for several periods by the owner. Costs incurred for expendable items during the year have a direct component and an opportunity cost component for the funds tied up in the purchase. Costs for expendables at the end of the year have only a direct component because there is no explicit or implicit interest charge. Capital items will have only an opportunity cost because they are still available at the end of the year (though perhaps with a different service potential).

Estimating the Costs of Capital Services

The basic equation for estimating capital service costs is the standard present value recursion

$$V_1 = (1 + i)V_0 - R_1 \qquad \textbf{(2.18)}$$

where V_1 is the nominal value of the asset at the end of the first period, V_0 is the nominal value at the end of the 0th period, and R_1 is a net cash flow occurring at the end of period 1. If the value of the asset in the two periods is known, then an implicit value for R_1 can be obtained by rearranging equation 2.18 as follows:

$$R_1 = iV_0 + (V_0 - V_1). \qquad \textbf{(2.19)}$$

The change in the value of an asset (V_0 - V_1), plus the opportunity cost of holding the asset (iV_0), is sometimes called **ownership cost**. Thus equation 2.19 implies that net cash flows are equal to ownership cost.

The **change in the value of an asset over a period (V_0 - V_1) is called economic depreciation**. For the general time period t, economic depreciation is given by (V_{t-1} - V_t). For an asset that is declining in value this will be a positive number and reflect a cost to the owner. Economic depreciation, which reflects changes in the market value of an asset between periods, is different from financial depreciation as computed for income tax purposes. Financial depreciation associated with buildings and equipment is the only type of depreciation that can be deducted for tax purposes. A landowner would consider changes in the productive capacity of land due to use in an economic analysis, but should not consider these in forming an income statement for tax purposes. An individual worker may consider a decline in her human capital as a hazard of holding a particular job, but her employer cannot usually deduct such an implicit cost for tax purposes.

The beginning value of the capital asset multiplied by the opportunity interest rate (iV_0) is called the **opportunity cost** of holding the asset and reflects compensation to the owner of the asset for the funds tied up in the asset over the period. Thus equation 2.19 implies that ownership costs are equal to opportunity cost plus economic depreciation.

Consider the example tractor where maintenance costs are treated as an expendable accounted for elsewhere rather than as a capital expense. The initial value is $30,000 and the final value before enhancement is $26,250. The implicit cost of holding the asset is then R_1 = (0.092)(30,000) + (30,000 - 26,250) = (1.092)(30,000) - 26,250 = $6,510. Alternatively, if the service enhanced value is used, the service enhancement cost of 1,050 is added to the implicit cost of the enhanced asset. The implicit cost of the service enhanced asset is (1.092)(30,000) - (27,300) = $5,460. The total cost is 5,460 + 1,050 = $6,510 as before.

Some of the costs associated with holding a capital asset occur simply because the capital is owned, some occur depending on its use, and some depend on the changes in the market price of a particular service capacity. Costs that occur simply **because the asset is held over a period are referred to as time costs**. The opportunity costs associated with the financial resources tied up in the capital asset are one form of time costs. The owner of the asset incurs an opportunity cost equal to the rate of return that the capital asset could earn if it were liquidated in the market and the funds reinvested. **Other time costs** include those costs associated with property taxes, general overhead, licenses, and insurance.

Measuring the Opportunity Costs of Capital

The opportunity cost for owned capital may be calculated by multiplying the beginning period value of the asset by the nominal next best rate of return. This next best rate of return is often proxied by the nominal interest rate so we obtain (iV_0) as in equation 2.19. This opportunity cost can also be obtained in a two-step procedure that measures the inflation component and then adds a measure of the real interest component. Alternatively, the opportunity cost can be calculated by measuring the real interest rate component and then adding an inflation component. The total opportunity cost will be the same in either case, but the division between components will differ depending on which adjustment was made first. The first method inflates the asset's beginning value to the end of the period using the inflation rate and then subtracts the beginning value to get the inflation component or equivalently multiplies the beginning-of- period value by the inflation rate. The inflation-adjusted end-of-period value is then multiplied by the real rate of interest implied by the next best investment opportunity to get the real interest component. The second approach multiplies the beginning-of-period value by the real interest rate then subtracts the beginning-of-period value to get a measure of the interest rate component. The real interest rate adjusted value is then multiplied by the inflation rate to get the inflation component. Both approaches assume that any capital gains implied by the nominal interest rate are accounted for in computing the asset's end-of-period market value. The first method is illustrated in equation 2.20a where the inflation adjustment is made first and it is assumed that the nominal interest rate is the next best available rate,

$$\begin{aligned} Opportunity\ cost &= V_0\, i \\ &= [V_0\,(1+p)]\, r + [V_0\,(1+p) - V_0] \\ &= V_0\, r + V_0\, p\, r + V_0 + V_0\, p - V_0 \\ &= V_0\,[r + p + p\, r] \\ &= V_0\, i\,. \end{aligned} \qquad \textbf{(2.20a)}$$

The second method is illustrated in equation 2.20b where the real interest rate adjustment is made first.

$$\begin{aligned} Opportunity\ cost &= V_0\, i \\ &= [V_0\,(1+r) - V_0] + [V_0\,(1+r)]\, p \\ &= V_0\, r + [V_0\,(1+r)\, p] \\ &= V_0\,[r + p + r\, p] \\ &= V_0\, i\,. \end{aligned} \qquad \textbf{(2.20b)}$$

Now consider computing the opportunity cost for the example tractor already discussed as presented in Table 2.10. The opportunity cost of the initial investment of $30,000 can be computed in one of two ways. The first is to multiply the initial investment amount by the nominal rate of interest. This gives an end-of-period opportunity cost of holding the tractor of $2,760. This amount represents the real interest cost of holding the asset plus inflationary increase in V_0 over the period. This can also be obtained by inflating the value of the tractor to the end of the period using the inflation rate and then applying the real interest rate to this amount. Specifically, the $30,000 is inflated to an end-of-period value of $31,500. Thus the inflation cost of holding the tractor is $1,500. The end-of-period value is then multiplied by the implied real rate of return of 4% to obtain the real interest cost of $1,260. The total cost is $2,760, as before.

TABLE 2.10 Cost of Using a Tractor with Division of Components and No Service Enhancement (in $)

	Actual Cost/Ret.	Direct Period Cost	Opportunity Cost	Inflation Component	Interest Component	Direct + Opportunity Cost
Purchase	30,000.00	0.00	2,760.00	1,500.00	1,260.00	2,760.00
Maintenance	200.00	200.00	8.99	4.94	4.05	208.99
Serv. Decline	5,000.00	5,000.00	0.00	0.00	0.00	5,000.00
Price Change	-1,250.00	-1,250.00	0.00	0.00	0.00	-1,250.00
Total		3,950.00	2,768.99	1,504.94	1,264.05	6,718.99

It is of course arbitrary whether the real interest or inflation adjustment is made first. A different order will lead to a slightly different division among the components. For example, if the real interest adjustment were made first, the real interest component would be (1.04)30,000 - 30,000 = $1,200 and the inflation component would be (1.05)(31,200) - (31,200) = $1,560. The total is $2,760, as in the previous case.

Measuring Economic Depreciation

Economic depreciation is the change in the present value of an asset as time passes (V_0 - V_1). It is often useful to divide economic depreciation into costs that occur because of a **reduction in service potential** and those that occur due to **changes in market prices**. Costs that occur because the asset loses some of its service capacity during the period are called **service reduction costs**.

> The **service reduction costs** of holding a capital asset are the decline in the service capacity of the asset due to use and/or time. These costs are computed assuming constant real prices for the asset, and are given by multiplying the beginning-of-period market price for a unit of service by the amount that service potential (hours, years, quality-adjusted acres, etc.) declines during the period. Such service reduction can occur because of use or time, and may not be simply the number of hours the machine was used during the period. The amount of service capacity reduction that occurs in a given time period can be modified by use and/or care and maintenance.
>
>> **Service reduction due to use** is a decline in the service capacity of a capital asset due to operating, as opposed to not operating. These implicit costs occur because the use of the factor alters its future service potential. These costs are the real decline in service capacity and are not related to market prices. For example, using a tractor for more hours (or more intensive hours) during a period may reduce its expected useful life and its market value.

> **Service reduction due to time** is a decline in the original service capacity of a capital asset that occurs only as a result of the passage of time. Service reduction costs associated with time include only those that occur independent of market prices. For example, weather may reduce the life of a barn due to wear. Capital assets may also lose value over time due to obsolescence. A laborer's skills may no longer be adequate to perform previously performed tasks due to changes in technology (for example, the advent of computers).

The division of economic depreciation into service reduction and changes in market prices is seen most easily in the case where service potential is measured in a single dimension such as hours of remaining service. Let the market price of a unit of this asset service at the beginning of the period be given by p_b, the beginning service potential by q_b, and the ending service potential by q_e. The value of the amount of service reduction that occurs during the period is then computed as follows:

$$\begin{aligned} \textit{Service reduction cost} &= (p_b)\,(\textit{amount of service reduction}) \\ &= (p_b)\,(q_b - q_e)\,. \end{aligned} \qquad \textbf{(2.21)}$$

Consider the service reduction costs for the example tractor. These costs are given by multiplying the decline in use potential (250 hours) by the price per hour of use ($20) for a cost of $5,000 as shown in Table 2.10. The service reduction costs for the full decline in service potential of 250 hours are all charged in this case, and the costs associated with enhancing the service capacity back to 1,300 hours are not included.

Capital goods can change in value independent of service potential due to changes in the market price of the asset's services. The opportunity cost computed for a capital good should reflect the market value of a specific service capacity. The market value of a capital good at the end of a given period should reflect both the service reduction and service enhancement that occurred during the period, along with any changes in the market value. This leads to a definition of the price change costs of a capital asset.

> The **price change costs** of a capital good include costs associated with changes in the market value of a good with a fixed service flow during a single production period that occur because of general inflation or deflation, or changes in market conditions related to that specific capital item. However, there may be other market forces that must be accounted for separately. For example, the discovery that in ten years a road will be built on a particular farm changes the market value of the farm even though the services extracted in the current period have not changed. Or, there may be a change in the price of the product produced by a capital asset that changes the asset's value. These capital gains or losses are usually accounted for separately from the other costs of holding capital.

Price change costs for an asset are computed using the service potential at the end of the period and the change in price over the period. Specifically, if q_e is the service potential at the end of the period, and beginning and ending prices are given by p_b and p_e, respectively, the cost associated with a change in price is

$$Price\ change\ cost = q_e(p_b - p_e)\,. \tag{2.22}$$

With rising prices, the price change cost will be negative. The total cost due to service reduction and price changes is given by the beginning-of-period value minus the ending value, or

$$\begin{aligned} Service\ reduction\ cost + price\ change\ cost &= economic\ depreciation\ (ED) \\ &= beginning\ value - ending\ value \\ &= V_0 - V_1 \\ &= p_b q_b - p_e q_e \end{aligned} \tag{2.23}$$

where q_b is the beginning service potential. This can be clearly decomposed into the two components in equations 2.21 and 2.22 by subtracting and adding $p_b q_e$ from equation 2.23 as follows:

$$\begin{aligned} Service\ reduction\ cost + price\ change\ cost &= economic\ depreciation\ (ED) \\ &= p_b q_b - p_e q_e \\ &= p_b q_b - p_b q_e + q_e p_b - q_e p_e \\ &= p_b(q_b - q_e) + q_e(p_b - p_e)\,. \end{aligned} \tag{2.24}$$

Aggregate or representative farm CAR projections usually assume that market prices of capital assets increase or decrease only by the general rate of inflation. Given declining real prices of agricultural goods and increased productive potential of new technologies, this practice may only be reasonable for short-run analysis covering three to five years.

Consider now the price adjustments for the example. The general inflation will cause some increase in the tractor's value. This will help offset the other costs of the tractor. The return from inflating prices can be computed by multiplying the end-of-period useful life of the tractor (1,250 hours) by the change in price (-1) for a return of $1,250 or a cost of -$1,250. The costs associated with the change in the value of the tractor over the period, $3,750 (30,000 -26,250), are thus clearly given by the decline in service capacity ($5,000) plus the change in value due to the price increase (-$1,250), for a total of $3,750.

Measuring Service Enhancement Costs

The next category of costs is that associated with enhancing the productive capacity of an asset. The **service enhancement** costs of holding a capital good are the **direct costs of increasing the service capacity of the asset**. These are the costs of expendables and other capital services that are used to alter the productive capacity of the asset. Because these costs allow for the provision of services for more than the current time period, they are normally treated as an investment in a capital asset and not as a period expense when the asset is not sold at the end of the period but is held for future use. The most common way to do this is to consider them as an adjustment to the service capacity of the asset to which they are applied, and then use this adjusted service capacity as the basis for all future cost calculations for that asset. Alternatively, the service reduction cost can be reduced if the service enhancement cost is charged in the current period and the enhanced service capacity is used to compute that decline in cost and also the change in market value, if any.

Consider computing service enhancement costs for the example tractor. One way to handle this computation is to use the calculations as in Table 2.10 but increase the value of the tractor when performing the analysis for future periods. Thus, rather than using the ending period value of $26,250, a higher value reflecting the enhanced service capacity could be used. For the example, this higher market value is $27,300 [(1,300)(21)]. An alternative is to reduce the service reduction costs to the amount necessary to cover the net decline (after enhancement) in value, and then include the service enhancement costs in the calculation. This is done in Table 2.11.

TABLE 2.11 Cost of Using a Tractor with Division of Components and with Service Enhancement Costs Included (in $)

	Actual Cost/Return	Direct Period Cost	Opportunity Cost	Inflation Component	Interest Component	Direct + Opportunity Cost
Purchase	30,000.00	0.00	2,760.00	1,500.00	1,260.00	2,760.00
Maintenance	200.00	200.00	8.99	4.94	4.05	208.99
Serv. Decline	4,000.00	4,000.00	0.00	0.00	0.00	4,000.00
Serv. Enhanc.	1,050.00	1,050.00	0.00	0.00	0.00	1,050.00
Price Change	-1,300.00	-1,300.00	0.00	0.00	0.00	-1,300.00
Total		3,950.00	2,768.99	1,504.94	1,264.05	6,718.99

Service decline costs are given by net decline in use hours (now only 200 hours) multiplied by the beginning-of-period price ($20). Thus the total service decline costs are $4,000. Service enhancement costs are now included and the adjustment for price changes is based on the enhanced capacity of 1,300 hours. Specifically, the price change effect is based on the change in price of $1 (21-20) multiplied by the enhanced service capacity of 1,300 hours. The result is the same total cost of $6,718.99, as before.

Maintenance Costs

The **maintenance costs** of holding a capital asset are the expenses required to maintain the service potential of the asset at a reasonable level and to extract services for a single time period. Activities associated with these costs are not usually viewed as enhancing the service capacity of the capital asset in any significant way when determining its end-of-period value. For example, expenses such as fuel, oil, and other lubricants are usually considered operating costs associated with the use of machinery and are treated as expendable inputs. Fence repair on land might be considered a maintenance cost of holding land, and mandatory pesticide education classes might be considered a maintenance cost for a farm employee. These costs usually are charged to the user of the capital service rather than the owner, although the distribution can differ by rental arrangement and custom.

Consider maintenance costs for the example case. The direct cost of this expendable is $200. Because this cost occurs at midyear, it implies an opportunity cost equal to the amount ($200) multiplied by $(1+i)^{.5}$ minus the original amount ($200) for an inflation plus real interest cost of $8.99 [$(200)(1.092)^{.5}$ - 200]. This can also be obtained by adjusting the value to the end of the year using the inflation rate and then applying the implied real rate of interest to the inflation-adjusted amount. The inflation component is then $4.939 [$(200)(1.05)^{.5}$ - 200] and the real interest component is $4.058 [$(204.939)(1.04)^{.5}$ - 204.939]. The sum of these two is $8.99, after rounding.

As pointed out previously, activities that restore a capital asset's lost service capacity should not be considered an expense in the current period because the lost capacity is often charged against the asset as a service reduction cost. Such activities should be treated as service enhancement costs, which can then be treated as part of the potential service flow of the capital good. Care must be given to the estimation of service reduction, service enhancement, and maintenance costs as they affect the service potential in an interdependent manner. For example, if an engine loses 10% of its potential capacity during the period with regular maintenance, the 10% reduction in potential and the maintenance cost should be charged to the current period. If at the end of the period the owner makes a repair to restore 5% of the lost capacity, this should not be considered a cost in the current period unless an adjustment is made to the cost charged for reduced capacity. The most common procedure is to charge the full 10% service reduction cost and treat the 5% enhancement as an investment rather than a cost.

Combining the Costs of Capital Services

During a given production period, the owner of a resource incurs all the costs just outlined. Included are those costs associated with holding the asset over the period (including opportunity interest and other time costs), service reduction due to use and time, service enhancement, maintenance, and changes in price. A definition for the costs of owning and using a capital asset can be given as follows:

$$
\begin{aligned}
\textit{Capital service cost } (CSC) &= \textit{Opportunity cost} \\
&+ \textit{service capacity reduction cost} \\
&+ \textit{change in price of the capital asset's service capacity} \\
&+ \textit{service enhancement cost} \\
&+ \textit{maintenance cost} \\
&+ \textit{other time costs} \\
&= iV_0 + (V_0 - V_1) + C_1 \\
&= iV_0 + ED + C_1
\end{aligned}
\qquad \textbf{(2.25)}
$$

where economic depreciation (ED) is defined as service reduction plus price changes and is given by (V_0 - V_1), and C_1 represents maintenance, service enhancement, and other time costs adjusted to the end of period 1. Service enhancement costs are in parentheses to remind the reader that these costs are usually handled in conjunction with service reduction costs or the price change adjustments. The costs of using the example tractor can then be divided into the opportunity cost of invested capital at the original capacity (opportunity cost), the decline in useful value at the beginning-of-period prices (service reduction cost), the decline or increase in market price due to inflation, the costs of maintenance adjusted to the end of the period, service enhancement, and other time costs. The costs can also be written as the sum of direct costs \$3,950 (200+4,000+1,050-1,300) and opportunity costs \$2,768.99 (2,760+8.99). This gives a total cost of \$6,718.99.

Based on these CSCs, the capital good is then offered for use during a production period. A market-based definition for the costs of capital services specifies that the **cost of capital factor services for a given period is the market price the owner of the resource is able to obtain for these services**. In simplistic terms this is just the rental rate the owner is able to obtain for the use of the asset for a given time period. This is the cost that should be included in CAR estimates. When the firm operator owns a capital good and a market price is not available to value the service flow, the value can be proxied by the returns that should accrue to that asset in economic equilibrium. This is done by assuming that the capital service will be offered on the market for no less than the full costs of providing the service. Thus capital ownership and use cost can be used to proxy capital service cost. Preparers of CAR estimates often disregard maintenance costs in computing capital service costs because maintenance costs are usually included as an expendable item paid for by the user of the capital rather than the owner. This common practice may be suspect if repair and maintenance costs vary significantly over the life of the asset so that older assets have higher costs. It is also common to regard other time costs such as property taxes as an expendable if they are similar from year to year and can be accounted for as a general overhead expense that may or may not be allocated to a specific enterprise or use. Further, it is usually assumed that any service enhancement is treated as a separate investment. Thus, the most common approximation to use for capital services is

$$\begin{aligned} \textit{Capital service cost}\ (CSC) \equiv\ & \textit{Opportunity cost} \\ & + \textit{service reduction cost} \\ & + \textit{change in price of the capital asset's service capacity}. \end{aligned} \qquad \textbf{(2.26)}$$

Chapter 5 of this report contains more detail on computing maintenance costs, and Chapter 6 discusses other time costs plus those costs explicitly included in equation 2.26. For the example tractor, equation 2.26 gives a capital service cost of $6,510 (2,760+5,000-1,250). This total is less than the previous calculations by the cost of maintenance.

Sometimes it is useful to combine the opportunity cost and changes in price into a measure that gives the real cost of holding the asset accounting for price changes. This might be called **net opportunity cost**. In this case the formula is modified to read

$$\textit{Capital service cost}\ (CSC) \equiv \textit{Net opportunity cost} + \textit{service reduction cost}. \qquad \textbf{(2.27)}$$

In our tractor example, the net opportunity cost would be 2,760-1,250 = $1,510. Adding the service reduction costs of $5,000 gives the total cost of $6,510.

An alternative approach is to combine the terms concerning changes in value and add them to the opportunity costs as

$$\begin{aligned} \textit{Capital service cost}\ (CSC) \equiv\ & \textit{Opportunity cost} + \textit{service reduction cost} + \textit{change in price} \\ =\ & \textit{Opportunity cost} + \textit{Economic depreciation}\ (ED) \\ =\ & iV_0 + (V_0 - V_1) \end{aligned} \qquad \textbf{(2.28)}$$

which is the basic present value recursion used in equation 2.19. Substituting R_1 for capital service cost, this can be written as

$$R_1 = (1 + i)V_0 - V_1 .$$

Using Annuities to Value Owned Capital

Although the above procedures are appropriate for estimating the current costs of using specific capital assets with known beginning and ending values, it is often useful to estimate a representative cost of using more generic capital over several time periods. This is particularly true for assets with a fixed life that lose value due to both use and time. The most common examples are machinery and equipment. Because of the decline in value of these assets due to use or time, the opportunity costs associated with ownership will tend to decline. The rising value of a given quantity of remaining usage due to inflation will, however, tend to compensate for this fact. Thus it is sometimes useful to use as the cost of the capital asset, not its current cost as computed above but rather, an annuity payment that has the same present value. The cost will then be the same for all years of the asset's life and there is no arbitrariness in picking a given year to assess costs. This can be either a real annuity that has constant real but changing nominal value or a nominal annuity that is constant in nominal dollars. This annuity is often referred to as the capital service cost (CSC) of the asset because it represents the annual cost of obtaining the asset's services. The discussion that follows assumes that maintenance and other time costs are excluded from computation of the annuity and are accounted for elsewhere. A discussion of the more general case is contained in Appendix 2C and in Burt (1992).

The formula for a nominal annuity, a^{nom}, that has the same discounted value as the actual costs of an asset over an n period horizon is derived in Appendix 2B (2B.10). This assumes that the asset is purchased at a cost of V_0 at the beginning of year 1 and is sold with value V_n at the end of year n. The resulting annuity (a^{nom}) is given by

$$a^{nom} = CSC = \frac{\left(V_0 - \frac{V_n}{(1+i)^n}\right)}{\left(\frac{1 - \frac{1}{(1+i)^n}}{i}\right)}. \qquad \textbf{(2.29)}$$

The numerator in equation 2.29 is just the present value at the beginning of the first period of the stream of payments associated with holding the asset for n years. As an example, consider the tractor discussed previously, assuming 1,500 hours of useful life to this firm and a five-year time horizon. Assume that after five years the tractor is sold having a useful life of 250 hours. The useful life of the tractor when it is sold or traded is often called the **salvage life** of the tractor. The value of this salvage life is called **salvage value.** Using straight line physical depreciation over the five years gives annual depreciation of 250 hours. Alternative assumptions concerning depreciation are discussed in Chapter 6. Table 2.12 shows the initial investment, the service reduction costs, and market price change costs for each year over the five-year period assuming an inflation rate of 5% and a real interest rate of 4%. The annual capital cost is computed from equation 2.26 and is equal to ownership cost plus service reduction cost plus the change in the price. The first year cost is $6,510, as before. In the second year the cost is 26,250(0.092)+250(21) + (−1.05)(1,000) = $6,615. The reduction in service hours during this year is 250, and the beginning-of-year price of service is $21.00 per hour. At the end of the second year the tractor has 1,000 remaining service hours and the price of an hour of tractor time increases from $21.00 to $22.05 dollars per hour. The price increase thus helps reduce costs. The capital cost in the fifth year is $6,891.92. The value of these costs discounted to the end of the first period using the nominal interest rate of 9.2% is $28,272.278 and to the beginning of the first period is $25,890.3645. A nominal annuity paid at the end of each period beginning with the first that has the same value as this stream of $25,890.3645 is $6,690.7945. Thus a constant nominal payment of $6,690.7945 at the end of periods 1 through 5 has the same present value as the actual cost stream. This amount can be determined without computing the costs for each year by using equation 2.29. In this case V_0 is \$30,000. The salvage life of the asset is 250 hours. To obtain the salvage value, this quantity is multiplied by the price (adjusted for inflation) for the fifth period or $V_n = (250)(20)(1.05)^5 = (250)(25.53) = \$6{,}381.407$, which is the same as the ending value for the fifth year in Table 2.12. Substituting these values into equation 2.29 we have

$$a = \frac{\left(30000 - \frac{(20)(1.05)^5(250)}{(1.092)^5}\right)}{\left(\frac{1 - \frac{1}{(1.092)^5}}{.092}\right)}$$

$$= \frac{\left(30000 - \frac{6381.4078}{1.55279}\right)}{\left(\frac{1 - \frac{1}{(1.092)^5}}{.092}\right)} = \frac{(30000 - 4109.6355)}{\left(\frac{1 - \frac{1}{(1.092)^5}}{.092}\right)} \qquad \textbf{(2.30)}$$

$$= \frac{25890.3644}{3.86955} = 6690.7945\,.$$

This constant nominal amount accounts for the cost of using the asset over the five-year time horizon. This is not the actual cost for any one period, but is a constant amount (an annuity) with the same present value as the stream of actual costs. This annuity can also be obtained using the standard annuity functions available on business calculators or in spreadsheet programs (such as PMT in EXCEL). In using such canned procedures, $\left(V_0 - \frac{V_n}{(1+i)^n}\right)$, which equals 25,890.3644 in this problem, should be used as the present value of the annuity with the assumption that the payment is made at the end of the period.

An alternative to computing this constant nominal cost is to compute the real annuity that has the same value as a noninflationary return stream and then inflate the value of this annuity each year in the cost estimation. Thus, rather than using the nominal interest rate in equation 2.29, the real rate is used and the salvage value is expressed in constant end-of-year dollars. Because there is no inflation, V_n is computed assuming that prices are the same as at the beginning of the first period. This gives

$$a^r = \frac{\left(V_0 - \frac{V_n^r}{(1+r)^n}\right)}{\left(\frac{1 - \frac{1}{(1+r)^n}}{r}\right)} . \tag{2.31}$$

It is important to note that V_n^r in equation 2.31 is computed assuming no inflation but V_n in equations 2.29 and 2.30 assumes a constant inflation rate over the entire time horizon. For the example, the real annuity is given by

$$a^r = \frac{\left(30000 - \frac{(20)\times(250)}{(1.04)^5}\right)}{\left(\frac{1 - \frac{1}{(1.04)^5}}{.04}\right)} = 5815.6778 . \tag{2.32}$$

This is the real amount paid at the end of each period that has the same present value as the nominal stream in equation 2.30. Because inflation is 5% in the example, the actual amount to be charged in each period is given by the stream $a_j^r = a(1+p)^j$ or \$6,106.46, \$6,411.784, \$6,732.374, \$7,068.992, and \$7,722.4424. Rather than assuming a constant nominal amount in all years of \$6,690.79, this approach allows a real amount that grows with the rate of inflation. Thus for the first year the cost is \$6,106.46 rather than \$6,690.794. Note that the present value of this increasing stream is the same as the value of the constant stream of \$6,690.794. The first year cost of this increasing stream is also the cost that would be obtained if one were to consider inflation to occur during the first year and no inflation to occur thereafter. The annuity equivalent in this case is given by

$$a^m = \frac{\left((1+p)\, V_0 - \frac{V_n^m}{(1+r)^n}\right)}{\left(\frac{1 - \frac{1}{(1+r)^n}}{r}\right)} \tag{2.33}$$

where a_m denotes a mixed nominal and real annuity and V_n^m is the salvage value assuming that inflation occurs only during the first year. This annuity has the same present value as a return stream with no inflation after the first year discounted to the present. This is the same as the real annuity given in equation 2.31 multiplied by (1+p).

Consider now the example tractor where inflation is assumed to occur only for one year. The annuity is given by

$$a^m = \frac{\left((1.05)(30000) - \frac{(20)(1.05)(250)}{(1.04)^5}\right)}{\left(\frac{1 - \frac{1}{(1.04)^5}}{.04}\right)} = 6106.46 \qquad \textbf{(2.34)}$$

which is the same as the real annuity, \$5,815.677, multiplied by (1+p). The present value of this stream where the discount rate for the first year is i and for subsequent years is r is the same as for the previous two cases.

There is thus a choice when using an annuity to reflect the costs of a multiyear asset in cases where some magnitudes are in nominal terms. The nominal approach uses equation 2.29 and finds the constant nominal annuity that is equivalent to the nominal return stream where it is assumed that inflation continues at the current rate over the life of the asset. If this approach is used, all other costs and returns for future periods must also be in nominal terms. The adjusted real approach, which allows for inflation in the current period only, uses equation 2.31 to obtain a real annuity that is adjusted for inflation in the current period or uses the mixed annuity equation (2.33) to obtain an answer directly. The easiest solution is to compute a real annuity using 2.31 assuming that V_0 and V_n are both in beginning-of-period dollars, and then multiply this annuity by the assumed inflation rate. In the first case, a constant nominal amount will be used in all subsequent periods but in the latter case the amount will rise with the rate of inflation. Neither annuity is an exact cost for a given period but has the same present value as the exact stream.

The preceding discussion assumed the only costs associated with holding the asset over the five-year time horizon were the initial purchase costs plus the opportunity interest on the money tied up in this asset minus the present value of the income from salvaging the asset at the end of the time period. Thus the present value of the cost/income stream was simply $V_0 - \frac{V_n}{(1+i)^n}$. If other costs such as maintenance, service enhancement, or other time costs are part of the cost profile, then a year-by-year tabulation of the present value of costs/returns as demonstrated in Table 2.12 should be undertaken. Appendix 2C contains a more complete discussion.

VALUING THE CONTRIBUTION OF OPERATOR LABOR

All factors of production except the operator of the firm can be accounted for using the above concepts. Compensation for the operator of the firm is based on opportunity cost of off-farm work, or the return available in the next best alternative use of his time and effort. For example, the operator of a farm has an implicit cost of his farm hours that is the opportunity costs associated with the nonfarm use of these hours. The opportunity cost for the operator of a farm firm who also has the skills and experience equivalent to a factory worker is the going wage for manufacturing workers in the area. Ways of estimating the costs of the owner-operator's time are discussed in more detail in Chapter 8 on labor costs.

COLLECTING, CREATING, AND USING PRICE SERIES

Most historical data is collected in nominal terms for a specific month and year. When an historical estimate is created for a given year, this reported nominal data for that year is appropriate for developing a nominal CAR estimate. For projected estimates a monthly nominal value for the previous year might be used as a base projection that then be adjusted ahead by the annual rate of inflation. Another alternative is to collect nominal data for several past years, convert these to real terms as of month on interest in the base year, average them and then adjust them for inflation in the base year. Another option is to use an econometric forecasting model that accounts for seasonality and monthly inflation rates. Another method is to obtain dealer estimates for the month of use as compared to the time the data is collected prior to the preparation of the estimate. A common situation is one where there is a single nominal estimate for the previous year or the current year. A nominal estimate for a previous year may be updated using the inflation rate. Often the price reported or to be used for a given year is a nominal value for the entire year computed by averaging daily or monthly prices with equal weights as compared to a nominal value in the month of a given expenditure. Given this single observation and a rate of inflation, one may want to estimate monthly prices for the year that rise at the rate of inflation. What is wanted then is a real (and also nominal given the base period convention) price at the end of the year that when converted to monthly nominal prices has a simple average equal to the reported nominal average. Let $\overline{p}^{n}$ be the average nominal price for the year, p_j^n the nominal price in the j^{th} month and p_m the monthly rate of inflation computed from equation 2.12 where p. replaces i. We can then find the real (nominal) price at the end of the year (p^r) as follows

$$
\begin{aligned}
\bar{p}^{n} &= \frac{\sum_{j=1}^{12} p_j^{n}}{12} \\
p_j^{n} &= p^{r}(1+\pi_m)^{j-12} \\
\Rightarrow \bar{p}^{n} &= \frac{\sum_{j=1}^{12} p^{r}(1+\pi_m)^{j-12}}{12} \\
&= \frac{p^{r}\sum_{j=1}^{12}(1+\pi_m)^{j-12}}{12} \\
\Rightarrow p^{r} &= \frac{(12)(\bar{p}^{n})}{\sum_{j=1}^{12}(1+\pi_m)^{j-12}} \\
&= \frac{(12)(\bar{p}^{n})}{(1+\pi_m)\sum_{j=1}^{12}(1+\pi_m)^{(j-12-1)}} \\
&= \frac{(12)(\bar{p}^{n})}{(1+\pi_m)US_0(\pi_m,12)} .
\end{aligned}
\qquad \textbf{(2.35)}
$$

where the last equality comes from equation 2B.7 in Appendix 2B where π replaces i in the summation. Writing the expression this way allows the use of canned annuity procedures for computing p^r. The nominal price for each month is then computed as

$$p_j^{n} = p^{r}(1+\pi_m)^{j-12} \qquad \textbf{(2.36)}$$

where $p_{12}^{n} = p_r$.

PROFITS AND RESIDUAL RETURNS

The difference between the farm's revenue and costs leads to the concept of profit or residual returns.

> **Profits (residual returns)** to the firm (or enterprise) are the revenues from production minus all the market-determined costs of factors and the opportunity cost of the operator's time and any other unaccounted for resources. With equilibrium in competitive markets, costs of production should, on average, just equal returns. Thus, this residual return or profit

has an expected value of zero. Deviations from zero are due to randomness such as unusual geoclimatic conditions, market imperfections, errors in measurement, inclusion or exclusion of government program payments, or risk-averse behavior by some individuals or to the simple fact that the firm is not in an equilibrium situation. For these reasons, the profit of any one farm or even the average of all farms is probably not equal to zero in a given production period or year.

If the operator of a specific firm consistently obtains positive profits in a competitive environment, the opportunity cost of resources such as land or this person's unpaid labor are not being valued highly enough. For example, if this person has unusual allocative skills in farming and farming alone, the opportunity cost measure that is based on off-farm earning potential will understate the individual's true contribution to the profits of the firm. Even in situations where abnormally high profits are maintained by artificial means (government subsidy, tariffs, or quotas), these returns are normally bid into the costs of factors so that excess profits will be eliminated.

Residual returns to a given factor of production are the revenues from production minus the opportunity cost of the operator's time and the market-determined costs of all but that factor of production. With all other factors accounted for, any residual returns are said to accrue to this factor.

If the market-based costs of more than one factor are not accounted for then residual returns to the unvalued factors are exaggerated. As an example, analysts sometimes speak of a return to labor and management, or a return to operator-owned resources. Allocating this residual among the unvalued resources requires information concerning the marginal contributions of these resources to production. A difficulty with the residual method of imputing value is that all of the elements that cause economic profit to deviate from its long-run equilibrium get included in this unallocated residual. For example, if the farmer had exceptionally low barley yields this year due to drought and the resource being priced was operator labor, these low yields would all be attributed to operator labor, giving it a low value. In the same sense, if the unvalued resource were land, the land would have a low value. Year-to-year variations thus make imputations rather arbitrary and of limited usefulness. In addition, individual producers or groups of producers are rarely, if ever, in a long-run equilibrium, so that in any given situation residual returns measure more than a long-run return to management or entrepreneurial skill even if all other inputs are correctly measured and included.

The Task Force recommends that factors of production be valued based on market transactions and that the residual, if any, simply be denoted residual returns to unvalued resources.

OTHER CAR CONCEPTS

Accountants often use the concept of cash versus noncash costs in preparing cash flow statements. Cash costs also are often used in capital budgeting. Such a distinction is important for planning borrowing needs and the timing of operator withdrawals for own consumption, but is not a key factor in estimating CARs.

> **Cash costs** are costs that require a cash payment at the time the transaction occurs or during a specified reporting period such as a week or month. **Noncash** costs are those in which the timing of the physical use of resources and the cash payments differs.

Most costs associated with the acquisition of expendable inputs are cash costs. Some counter examples are feed produced during the current period that is fed to livestock and landlord-paid costs of inputs in a sharecropping arrangement. Depreciation costs associated with operator-owned capital goods such as equipment are always considered noncash costs, as are opportunity costs associated with holding capital goods.

It is also important to distinguish between economic cost concepts and finance terminology. Economic costs represent the valuation of all resources consumed during the course of a production period, regardless of ownership. Whether an individual production input is owned, financed, or leased is immaterial to the estimation of CARs, though it is very important to the management of an individual operation. From a resource perspective, the costs of one hour of service for a tractor that is owned and a tractor that is financed are identical because the values of the economic contributions of each to the production process are similar. The cash costs of each tractor do vary with asset ownership, however, because of the difference between interest and lease payments. The cash flow statements of two farmers who have debt levels of 0% and 50%, respectively, may differ because of financial payments, even though the two farmers may be using identical inputs and production practices in their farming operation (and therefore, have the same economic costs of production).

> ***The Task Force recommends that all costs and revenues associated with a given enterprise be adjusted (discounted) to the same point in time for the purposes of CAR estimation. The Task Force recommends that this point in time be the end of the production period. Because this approach applies implicit interest to all costs and returns, any costs associated with financing a given enterprise should not be included in the estimates.***

Another common distinction is between fixed and variable costs. This distinction depends on the range of choices considered available to the firm in the currently defined decision period. Currently available choices are inputs whose level of use and thus cost is not already determined. For example, once a feeder lamb reaches 100 pounds, the farmer cannot decide to change the amount and cost of the oats consumed. A specific time period is often associated with the decision problem so that what is fixed and variable changes depending on the time period considered.

> **Fixed costs** are those costs that the firm is committed to pay to factors of production regardless of the firm's action in the currently defined decision period. They are costs that are not affected by the current set of decisions. If some choices are fixed for a given decision problem, then costs associated with them are also fixed.

Variable costs are those costs that are affected by the firm's actions in the currently defined decision period. Variable costs occur because of the decision to purchase additional factors or factor services for use in production.

The time period under consideration clearly affects the delineation of fixed and variable factors and associated costs. For example, if a tractor is leased (with no possibility of re-leasing) on an annual basis, the cost of the lease is fixed when deciding whether to produce cotton or tomatoes, but the per acre charge for custom harvesting is variable when deciding whether to harvest a damaged crop. Once the owner of a resource decides to assume ownership for another period, the ownership costs, service reduction costs due to time, and potential price gains are fixed. If the owner considers selling the services of a capital good along with using the services internally then the portion of the fixed charges to allocate to internal operations is variable depending on use. As irreversible decisions on input use are made, costs that were previously variable become fixed. In this vein, the costs of all expendable inputs are variable until they are contracted for use. For operator-owned capital goods, the costs are fixed once the operator decides to maintain the asset for another period.

The fact that operators of farms often own some of the resources used in production has led many analysts to classify the associated service flows as being fixed in the sense that the owner of the resource (and in this case the operator of the firm) incurs the ownership costs regardless of the amount of product produced. These analysts have then called these ownership costs "fixed costs" because they are associated with the "fixed" factors. This has caused great confusion as to the meaning of fixed and variable costs, the costs of ownership, and the costs of use. The difficulty found in labeling costs as fixed or variable has led some researchers to use the categories “ownership” and “operating costs.” However, because most farm and ranch operators combine ownership with use, the categorization and measurement of CARs in these categories is less clear.

Furthermore, each firm or composite of firms operates with a different mix of owned and purchased inputs and different combinations of fixed and variable factors of production. Problems with the categorizations of fixed and variable costs are further compounded by the fact that accounting measures typically include all variable costs, some fixed costs, and direct use costs (but not returns) if the operator is an owner of factors. Accounting measures rarely (except in the case of depreciation) include the imputed CARs of operator-owned resources. Accountants, in particular, prefer the distinction between cash and noncash costs. As a result, the terminology commonly used tends to be confusing.

The Task Force therefore recommends that costs should be categorized only as to whether they are associated with expendable factors or the services of capital assets. The division of costs into categories such as fixed and variable should generally be avoided in preparing CAR estimates. For the purpose of preparing CAR estimates for specific enterprises, the Task Force recommends that all the costs of all expendables be allocated to the generic group OPERATING COSTS and that all other costs be allocated to the group ALLOCATED OVERHEAD.

TABLE 2.12 Annuities and Multiperiod Costs

Annual real interest rate	4%	Salvage life	250 hrs.
Annual inflation rate	5%	Life in years	5
Annual nominal interest rate	9.2%	Annual depreciation	250 hrs.
Original life of asset	1,500 hrs.	Initial price	$20 per hour

Year	Item	Beg. Price	Beg. Quantity	Beg. Value	Opp. Cost	Inflation	Interest	End Price	End Quantity	End Value	Cost
1	Investment	20	1,500	30,000	2,760	1,500	1,260	21	1,250	26,250	2,760
	Service reduction										5,000
	Price change										-1250
	Total cost										6,510
	Constant nominal annuity										6,690.795
	Infla. adj. real annuity										6,106.462
2	Investment	21	1,250	26,250	2,415	1,312.5	1,102.5	22.05	1,000	22,050	2,415
	Service reduction										5,250
	Price change										-1,050
	Total cost										6,615
	Constant nominal annuity										6,690.795
	Infla. adj. real annuity										6,411.784
3	Investment	22.05	1,000	22,050	2,028.	1,102.5	926.1	23.15	750	17,364.	2,028.6
	Service reduction										5,512.5
	Price change										-826.875
	Total cost										6,714.225
	Constant nominal annuity										6,690.795
	Infla. adj. real annuity										6,732.374
4	Investment	23.152	750	17,364.	1,597.	868.219	729.304	24.31	500	12,155.	1,597.523
	Service reduction										5,788.125
	Price change										-578.813
	Total cost										6,806.835
	Constant nominal annuity										6,690.795
	Infla. adj. real annuity										7,068.993

TABLE 2.12 (continued)

5	Investment	24.310	500	12,155.	1,118.	607.753	510.513	25.53	250	6,381.4	1,118.266
	Service reduction										6,077.531
	Price change										-303.877
	Total cost										6,891.920
	Constant nominal annuity										6,690.795
	Infla. adj. real annuity										7,422.442
	US_0 (.04, 5)	4.45182233									
	US_0 (.092, 5)	3.86955005									
	P.V. of annual costs at end of 1st period										28,272.278
	P.V. of annual costs at beginning of 1st period										25,890.365
	P.V. of nominal annuity at end of 1st period										28,272.278
	P.V. of inflated real annuity at end of 1st period										28,272.278
	Annual nominal annuity with present value beginning of 1st period of 25,890.86										6,690.795
	Annual real annuity with present value at beginning of 1st period of 25,890.86										5,815.68

APPENDIX 2A

Separating Real Interest Charges and Inflation from Nominal Interest Charges

The appropriate way to adjust any cost or expenditure (R) occurring n months from the end of the period to the end of the period (year or last year in the case of multiyear periods) year is to use the formula given in equation 2.2,

$$V_0 = \sum_{t=-n}^{0} \frac{R_t}{(1+i)^t} . \qquad \textbf{(2.2)}$$

If there is only one payment and it occurs j-months from the end of the year, then the value of this payment at the end of the year is given by

$$V_0 = \frac{R_t}{(1+i_m)^{-j}}$$

where i_m is the monthly interest rate and j denotes the number of months that the expenditure occurs from the beginning of the year. We can write this in several alternative ways as follows:

$$V_0 = \frac{R}{(1+i_m)^{-n}} = R(1+i_m)^n = R(1+i)^{n/12}$$

where V_0 is the value of the expenditure at the end of the period, and i_m is the monthly interest rate, and n now denotes the number of months the expenditure occurs from the end of the year. The interest cost for this adjustment is given by either equation 2.14 or 2.15,

$$ic = R(1+i_m)^n - R \qquad \textbf{(2.14)}$$

$$ic = R(1+i)^{\frac{n}{12}} - R . \qquad \textbf{(2.15)}$$

The results of using this procedure for the cotton cost example were contained in Table 2.2 of Chapter 2. In order to divide the nominal interest cost into inflation and real interest rate components it is necessary to compute an inflation rate compatible with the given real and nominal interest rates. This can be done on both an annual and a monthly basis. The first step is to find the annual inflation rate using the Fisher formula p = (i- r)/(1 + r). Consider the example in Table 2A.1 (Inflation and Real Interest Division). Here an annual nominal interest rate of 10% and an annual real interest rate of 3% are assumed. The implied annual inflation rate is then (.1 - .03)/(1.03) = .067961. Once the annual inflation rate is known, implied monthly rates for nominal and real interest and inflation can be obtained using the relations

$$
\begin{aligned}
i_m &= (1+i)^{\frac{1}{12}} - 1 \\
r_m &= (1+r)^{\frac{1}{12}} - 1 \\
p_m &= (1+p)^{\frac{1}{12}} - 1
\end{aligned}
\qquad \textbf{(2A.1)}
$$

where no subscript implies an annual rate and subscript m denotes a monthly rate. For the example case this gives an implied monthly real rate of $r_m = (1.03)^{1/12} - 1 = .002466$ and an implied monthly inflation rate of $p_m = (1.0679)^{1/12} - 1 = .005494$. The Fisher formula implies that (1 + r) (1 + p) = 1 + i. Using the above identities, it also implies that $(1+r_m)(1+p_m) = 1 + i_m$ because $(1+r)^{1/12}(1+p)^{1/12} = (1+i)^{1/12}$. These relations are used in allocating the nominal interest charges to inflation and real interest.

The Fisher relation specifies that the product of (1+r) and (1+p) equals 1+i. The relationship is thus multiplicative and not additive and so any division between inflation and real interest is somewhat subjective for any discrete time period. Specifically, part of the adjustment of a cost or return variable is due to real interest (r), part is due to inflation (p), and part is due to the cross product term (pr). Any additive division of this cross product term is arbitrary. Rather than arbitrarily allocate this factor, the common practice is to explicitly attribute it to either the real interest or inflation component by sequentially making the adjustments. An example helps make this clear. Consider an expense of $500 occurring six months before the end of the year with a nominal interest rate of 8% and a real rate of 3%. Using equation 2.15 and a nominal interest rate of 8% gives a nominal interest cost of $(500)(1.08)^{½} - (500) = \$19.615$. The annual inflation rate compatible with an 8% nominal rate and a 3% real rate is given by (.08-.03)/(1.03) = .04854 = 4.854%. Consider making the inflation adjustment first. The inflation adjusted value of $500 for six months is given by $(500)(1.04854)^{½} = \$511.992$. This gives an inflation cost of $(500)(1.04854)^{½} - 500 = \$11.992$. This inflation-adjusted amount is then adjusted using the real interest rate. This will give an inflation- and real interest-adjusted amount of $511.992(1.03)^{.5} = \$519.615$, which is exactly the same as obtained using the nominal rate. The real interest component is then computed as this **inflation- and real interest-adjusted** amount minus the **inflation-adjusted** amount. For the example this gives 519.615 - 511.992 = $7.623. The total of the inflation costs (11.992) and the real interest costs (7.623) equals the total nominal interest cost of $19.615. What is arbitrary is performing the inflation adjustment first because this implies that the real interest is assessed on a larger value than the original unadjusted amount. An alternative is to make the real interest adjustment first. This gives a real interest-adjusted amount of $500(1.03)^{.5} - 500 = \$507.445$ or a real interest cost of $7.445, which is less than before. This real interest-adjusted amount is then adjusted using the inflation rate and yields a total adjusted value of $507.445(1.04854)^{.5} = \$519.615$ or a total nominal interest cost of $19.615. The inflation adjustment is given by subtracting the real interest-adjusted value from the total or 519.615 - 507.445 = $12.17, which is larger than before because the inflation adjustment is applied to the larger real interest-adjusted amount. The total of the inflation ($12.17) and real interest ($7.445) cost is equal to the total nominal cost ($19.615).

Now consider the example in the first part of Table 2A.1 where the inflation adjustment is made first. In the first step the actual charge is adjusted to the end of the year using the implied monthly inflation rate. The adjustment factor is $(1 + p)^{n/12}$. For example, the inflation-adjusted cost of fertilizer is $(24.45)(1.0679)^{10/12}$ = \$25.827. This could also be computed using the implied monthly rate and the formula $(1 + p_m)^n$, which gives $(24.45)(1.005494)^{10}$ = \$25.827. The inflation cost is then found by subtracting the initial unadjusted cost or

$$pc = actual\ cost\ (1 + p)^{n/12} - actual\ cost \qquad \textbf{(2A.2)}$$

where pc is the cost associated with inflation. For the example this gives \$1.3771. Once all costs are adjusted to the end of the year using the implied inflation rate, the real interest cost can be obtained using the formula

$$ric = inflation\text{-}adjusted\ cost\ (1 + r)^{n/12} - inflation\text{-}adjusted\ cost \qquad \textbf{(2A.3)}$$

where ric is the real interest cost and r is the real annual interest rate. For example, the real interest on the fertilizer expense is given by $(25.827)(1.03)^{10/12}$ - 25.827 = .644. The total of the real interest costs and inflation costs is .644 + 1.3771 = 2.021, which is the same as that computed using the direct nominal rate. Thus the nominal interest can be divided into real interest and inflation components using the suggested procedure.

Now consider making the real interest adjustment first in the second portion of Table 2A.1. In the first step the actual charge is adjusted to the end of the year using the implied monthly real interest rate. The adjustment factor is $(1 + r)^{n/12}$. For example, the real interest-adjusted cost of fertilizer is $(24.45)(1.03)^{10/12}$ = \$25.06. The real interest cost is then found by subtracting the initial unadjusted cost or

$$ric = actual\ cost\ (1 + r)^{n/12} - actual\ cost \qquad \textbf{(2A.4)}$$

where ric is the cost associated with real interest. For the example this gives \$0.6097. Once all costs are adjusted to the end of the year using the real interest rate, the inflation cost can be obtained using the formula

$$pc = real\ interest\text{-}adjusted\ cost\ (1 + p)^{n/12} - real\ interest\text{-}adjusted\ cost \qquad \textbf{(2A.5)}$$

where pc is the inflation cost and p is the annual inflation rate. For example, the inflation cost on the fertilizer expense is given by $(25.06)(1.0679)^{10/12}$ - 25.06 = \$1.411. The total of the real interest costs and inflation costs is .6097 + 1.411 = \$2.021, which is the same as that computed using the direct nominal rate and the inflation first assumption. Clearly, the two assumptions lead to slightly different allocations of real interest and inflation. The more common approach is to make the real interest rate adjustment first because with low inflation, real interest is the more important issue; however, there is no compelling argument for doing so.

The Task Force recommends that when decomposing nominal interest magnitudes into real interest and inflation components, one of the above procedures which compound interest during the year and take explicit account of the interactions of interest rates and inflation be used. Other procedures using proportional interest or ignoring the interaction effects should be viewed as approximations only.[4]

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[4]A difficulty with using the proportional methods of computing interest is that the decomposition is inconsistent. This leads to problems because the Fisher formula (1+r)(1+p) = 1+i cannot hold at both an annual and subperiod level if the rule for determining monthly rates is $r_m = (n/12)(r)$ rather than $r_m = (1 + r)^{1/12} - 1$. To see this, multiply out the implied monthly Fisher relation. The only way to obtain consistency is to allow the implied inflation rate to differ for each subperiod and not be computed using $p_m = (n/12)(p)$ or $p_m = (1 + p)^{1/12} - 1$.

TABLE 2A.1 Inflation and Real Interest Division

Enterprise termination date is 1 Dec.
Annual nominal and real interest rates are used to impute an annual inflation rate using the Fisher equation
Actual costs are adjusted to the end of the period using implied monthly inflation rates
Implied monthly real rates are applied to the inflation-adjusted costs
Annual nominal interest rate is 0.1 = 10%
Implied monthly rates are computed using the formula $i_m = (i + 1)^{n/12} - 1$
Implied monthly nominal rate is 0.007974 = .7494%
Annual real interest rate is 0.030000 = 3%
Implied monthly real interest rate is 0.002466 = .2466%
Implied annual inflation rate is 0.067961 = 6.796%
Implied monthly inflation rate is 0.005494 = .5494%
Inflation-adjusted cost = (Actual cost) $(1+p)^{n/12}$
Real interest charge = (Adjusted cost)$(1+r)^{n/12}$ - (Adjusted cost)

A. Inflation and Real Interest Division with Inflation Adjustment First

Item	Time of Use	Actual Cost	Months Used	Real Interest-Adjusted Cost	Inflation Cost	Inflation on Adjusted Cost	Nominal Interest
Fertilizer	1 Feb	24.45	10	25.8271	1.3771	0.644	2.021
Cotton Seed	1 Apr	17.28	8	18.0543	0.7743	0.359	1.134
Insecticide	1 Jul	20.00	5	20.5555	0.5555	0.255	.810
Insecticide	1 Aug	20.00	4	20.4432	0.4432	0.202	.646
Insecticide	1 Sep	20.00	3	20.3315	0.3315	0.151	.482
	Total	101.73		105.212	3.4815	1.6113	5.093
	Inflation Adjustment	3.482					
	Real Interest	1.611					
Total Cost		106.823					

Table 2A.1 (continued)
B. Inflation and Real Interest Division with Real Interest Adjustment First

Item	Time of Use	Actual Cost	Months Used	Real Interest-Adjusted Cost	Real Interest Cost	Inflation on Adjusted Cost	Nominal Interest
Fertilizer	1 Feb	24.45	10	25.060	.6097	1.411	2.021
Cotton Seed	1 Apr	17.28	8	17.624	.3439	0.790	1.134
Insecticide	1 Jul	20.00	5	20.248	.2478	0.562	.810
Insecticide	1 Aug	20.00	4	20.198	.1980	0.448	.646
Insecticide	1 Sep	20.00	3	20.148	.1483	0.334	.482
	Total	101.73		103.278	1.5479	3.5450	5.093
	Inflation Adjustment	3.545					
	Real Interest	1.547					
Total		106.823					

APPENDIX 2B

Derivation of Annuity Formulas

Preparers of CAR estimates may prefer to represent the capital service cost of capital assets with an annuity payment rather than the period-by-period costs for ownership, service reduction, and change in price. This can be either a real annuity that has a constant real but changing nominal value or a nominal annuity that is constant in nominal dollars. The annuity formulas are derived here. Numerical examples are given in Chapter 2.

Present Value of a Return Stream

One can compute the present value of an infinite stream of payments using the present value recursion given in Chapter 2, equation 2.18 where V_n is a value at the end of the n^{th} period, V_0 is a value at the beginning of the first period, and R_n is a payment at the end of the n^{th} period. Beginning with n =1 and continuing to substitute for V_n we obtain

$$\begin{aligned} V_1 &= (1+i)V_0 - R_1 \\ \Rightarrow V_0 &= \frac{R_1}{1+i} + \frac{V_1}{1+i} \\ &= \frac{R_1}{1+i} + \frac{R_2}{(1+i)^2} + \frac{V_2}{(1+i)^2} \\ &= \frac{R_1}{1+i} + \frac{R_2}{(1+i)^2} + \cdots + \frac{R_n}{(1+i)^n} + \frac{V_n}{(1+i)^n} \\ &= \sum_{t=1}^{\infty} \frac{R_t}{(1+i)^t}. \end{aligned} \tag{2B.1}$$

In a similar way one can compute the value at the end of period n of a stream of payments beginning at the end of period n+1 as

$$\begin{aligned} V_n &= \frac{R_{n+1}}{1+i} + \frac{V_{n+1}}{1+i} \\ &= \frac{R_{n+1}}{1+i} + \frac{R_{n+2}}{(1+i)^2} + \cdots + \\ &= \sum_{t=1}^{\infty} \frac{R_{t+n}}{(1+i)^t} \\ &= \sum_{t=n+1}^{\infty} \frac{R_t}{(1+i)^{t-n}} \\ &= (1+i)^n \sum_{t=n+1}^{\infty} \frac{R_t}{(1+i)^t}. \end{aligned} \tag{2B.2}$$

The formula for V_0 can then be written as the sum of R_t over n time periods plus the residual value for V_n as follows:

$$V_0 = \sum_{t=1}^{n} \frac{R_t}{(1+i)^t} + \frac{V_n}{(1+i)^n}. \tag{2B.3}$$

This can be rearranged to express the present value of the returns at the end of each of n time periods as a function of V_0 and V_n as

$$\sum_{t=1}^{n} \frac{R_t}{(1+i)^t} = V_0 - \frac{V_n}{(1+i)^n}. \tag{2B.4}$$

Notice that the left-hand side of 2B.4 is the present value of the payment stream discounted to the beginning of the first period (end of period 0). Multiplying equation 2B.4 by (1+i) gives the value of the payment stream at the end of period 1 as

$$\begin{aligned} (1+i)\left[\sum_{t=1}^{n} \frac{R_t}{(1+i)^t}\right] &= (1+i)\left[V_0 - \frac{V_n}{(1+i)^n}\right] \\ \Rightarrow \sum_{t=1}^{n} \frac{R_t}{(1+i)^{t-1}} &= (1+i)\left[V_0 - \frac{V_n}{(1+i)^n}\right]. \end{aligned} \tag{2B.5}$$

Calculation of an Annuity Payment Representing a Present Value

We can calculate an annuity (a) with n equal payments at the end of each period having the same value as the left-hand side of equation 2B.4. Specifically, we find a uniform payment (a) to be received (or dispersed) at the end of each period that has the same present value at time zero as the sum of the R_t each discounted to time zero. The annuity (a) is implicitly defined by writing out this identity for $\sum_{t=1}^{n} \frac{R_t}{(1+i)^t}$,

$$\frac{a}{1+i} + \frac{a}{(1+i)^2} + \cdots + \frac{a}{(1+i)^n} = \frac{R_1}{1+i} + \frac{R_2}{(1+i)^2} + \cdots + \frac{R_n}{(1+i)^n}$$

$$\Rightarrow a \sum_{t=1}^{n} \frac{1}{(1+i)^t} = \sum_{t=1}^{n} \frac{R_t}{(1+i)^t} \tag{2B.6}$$

$$\Rightarrow a = \frac{\sum_{t=1}^{n} \frac{R_t}{(1+i)^t}}{\sum_{t=1}^{n} \frac{1}{(1+i)^t}}.$$

The expression in the denominator of 2B.6 is a geometric series that can be simplified. Let this denominator be denoted by $US_0(i,n)$ meaning a uniform series having interest rate i and n periods. Specifically, let $US_0(i,n)$ be defined as

$$US_0(i,n) = \left(\frac{1}{1+i} + \frac{1}{(1+i)^2} + \cdots + \frac{1}{(1+i)^n} \right)$$

$$= \sum_{t=1}^{n} \frac{1}{(1+i)^t}. \tag{2B.7}$$

Now multiply $US_0(i,n)$ by 1/(1+i) and then subtract from $US_0(i,n)$ as follows:

$$US_0(i,n) - \left[\frac{1}{1+i}\right]US_0(i,n) = \left[\left(\frac{1}{1+i} + \frac{1}{(1+i)^2} + \ldots + \frac{1}{(1+i)^n}\right) - \left(\frac{1}{(1+i)^2} + \frac{1}{(1+i)^3} + \ldots + \frac{1}{(1+i)^{n+1}}\right)\right]$$

$$= \frac{1}{1+i} - \frac{1}{(1+i)^{n+1}}$$

$$\Rightarrow (1+i)US_0(i,n) - US_0(i,n) = 1 - \frac{1}{(1+i)^n}$$

$$\Rightarrow i\ US_0(i,n) = 1 - \frac{1}{(1+i)^n} \qquad \textbf{(2B.8)}$$

$$\Rightarrow US_0(i,n) = \frac{\left(1 - \frac{1}{(1+i)^n}\right)}{i}.$$

Thus by sequentially substituting 2B.8 into 2B.7 and then into 2B.6 we obtain

$$a = \frac{\sum_{t=1}^{n} \frac{R_t}{(1+i)^t}}{\sum_{t=1}^{n} \frac{1}{(1+i)^t}}$$

$$= \frac{\left(\sum_{t=1}^{n} \frac{R_t}{(1+i)^t}\right)}{\left[\frac{1 - \frac{1}{(1+i)^n}}{i}\right]}. \qquad \textbf{(2B.9)}$$

Equation 2B.9 gives an annuity payable at the end of each period that has the same discounted value at the beginning of the time frame as the actual payments over the n period time horizon. If we then substitute 2B.4 for the numerator in 2B.9 we obtain

$$a^{nom} = \frac{\left(V_0 - \frac{V_n}{(1+i)^n}\right)}{\left(\frac{1 - \frac{1}{(1+i)^n}}{i}\right)}. \qquad \textbf{(2B.10)}$$

If all values are expressed in real terms, then a real annuity with equivalent present value to 2B.10 is given by

$$a^{r} = \frac{\left(V_0 - \frac{V_n}{(1+r)^n}\right)}{\left(\frac{1 - \frac{1}{(1+r)^n}}{r}\right)} \qquad \textbf{(2B.11)}$$

where V_0 and V_n are expressed in real dollars. This is the annuity payment in real terms in the base period. To find the nominal payment that is to be made in other periods, this amount is adjusted by the inflation rate. Specifically, the nominal payment in the j^{th} period from the base is $a_j = a^r(1+p)^j$ where p is the constant rate of inflation per period.

The nominal first year payment of this increasing stream is also the payment that would be obtained if one were to assume that inflation occurs only during the first year and no inflation occurs thereafter. To see this, recompute the present value recursion using a nominal interest rate for the first year and a real interest rate for subsequent years.

$$\begin{aligned}
V_1 &= (1+i)V_0 - R_1 \\
\Rightarrow V_0 &= \frac{R_1}{1+i} + \frac{V_1}{1+i} \\
V_2 &= (1+r)V_1 - R_2 \\
\Rightarrow V_1 &= \frac{R_2}{1+r} + \frac{V_2}{1+r} \\
\Rightarrow V_0 &= \frac{R_1}{1+i} + \frac{R_2}{(1+i)(1+r)} + \frac{V_2}{(1+i)(1+r)} \\
&= \frac{R_1}{1+i} + \frac{R_2}{(1+i)(1+r)} + \cdots + \frac{R_n}{(1+i)(1+r)^{n-1}} + \frac{V_n}{(1+i)(1+r)^{n-1}} \\
&= \frac{1}{1+i} \sum_{t=1}^{n} \frac{R_t}{(1+r)^{t-1}} + \frac{V_n}{(1+i)(1+r)^{n-1}} \\
&= \frac{1}{1+i} \sum_{t=1}^{\infty} \frac{R_t}{(1+r)^{t-1}} .
\end{aligned} \tag{2B.12}$$

We can rearrange the next to last expression in 2B.12 to give the present value of the payment stream at the beginning of the time horizon assuming inflation in only the first period:

$$\begin{aligned}
\frac{1}{1+i} \sum_{t=1}^{n} \frac{R_t}{(1+r)^{t-1}} &= V_0 - \frac{V_n}{(1+i)(1+r)^{n-1}} \\
\Rightarrow \sum_{t=1}^{n} \frac{R_t}{(1+r)^{t-1}} &= (1+i)\,V_0 - \frac{V_n}{(1+r)^{n-1}} .
\end{aligned} \tag{2B.13}$$

An annuity with n equal payments at the end of each period that has the same present value as the left-hand side of 2B.13 is computed from

$$\begin{aligned}
&\frac{R_1}{1+i} + \frac{R_2}{(1+i)(1+r)} + \dots + \frac{R_n}{(1+i)(1+r)^{n-1}} = \frac{a^m}{1+i} + \frac{a^m}{(1+i)(1+r)} + \dots + \frac{a^m}{(1+i)(1+r)^{n-1}} \\
&\Rightarrow a^m \left(\frac{1}{1+i}\right) \sum_{t=1}^{n} \frac{1}{(1+r)^{t-1}} = \left(\frac{1}{1+i}\right) \sum_{t=1}^{n} \frac{R_t}{(1+r)^{t-1}} \\
&\Rightarrow a^m = \frac{\sum_{t=1}^{n} \frac{R_t}{(1+r)^{t-1}}}{\sum_{t=1}^{n} \frac{1}{(1+r)^{t-1}}} \\
&= \frac{\sum_{t=1}^{n} \frac{R_t}{(1+r)^{t-1}}}{(1+r) \sum_{t=1}^{n} \frac{1}{(1+r)^{t}}} \\
&= \frac{\sum_{t=1}^{n} \frac{R_t}{(1+r)^{t-1}}}{(1+r)\ US_0(r,n)}
\end{aligned} \qquad \textbf{(2B.14)}$$

where the superscript m on “a” denotes a mixed annuity that will be the same for all periods assuming inflation in the first year and none thereafter. If we substitute the expression for US_0(r,n) into 2B.14 and then substitute 2B.13 for the numerator in 2B.14 we obtain

$$
\begin{aligned}
a^m &= \frac{\sum_{t=1}^{n} \frac{R_t}{(1+r)^{t-1}}}{(1+r)\left(\frac{1-\frac{1}{(1+r)^n}}{r}\right)} \\
&= \frac{(1+i)V_0 - \left(\frac{V_n}{(1+r)^{n-1}}\right)}{(1+r)\left(\frac{1-\frac{1}{(1+r)^n}}{r}\right)} \\
&= \frac{\frac{(1+i)}{(1+r)}V_0 - \left(\frac{V_n}{(1+r)^n}\right)}{\left(\frac{1-\frac{1}{(1+r)^n}}{r}\right)} \qquad \textbf{(2B.15)} \\
&= \frac{(1+p)V_0 - \frac{V_n}{(1+r)^n}}{\left(\frac{1-\frac{1}{(1+r)^n}}{r}\right)} \\
&= \frac{(1+p)\left[V_0 - \frac{V_n}{(1+p)(1+r)^n}\right]}{\left(\frac{1-\frac{1}{(1+r)^n}}{r}\right)}.
\end{aligned}
$$

This then is a constant annuity payable at the end of each period that has the same present value as a return stream having inflation in the first year and no inflation thereafter discounted to the present. It is easy to see that this is the same as the real annuity given in equation 2B.11 multiplied by (1+p) because V_n in equation 2B.15 (where there is one year of inflation) will be the same as V_n in equation 2B.11 multiplied by (1+p).

General Annuities

Annuities can also be developed for subperiods of time and for alternative compounding scenarios. For example, we might choose to create an annuity making payments every six months to represent the present value of an income stream with payments at the end of each year. Alternatively, we may want to create a fractional annuity that makes one payment a year for 5 years and makes a final payment at 5 ½ years. This type of annuity may be useful for income or cost streams associated with assets that are sold or traded at noninteger time intervals.

The easiest way to compute such annuities is to use the fractional period interest formulas given in equations 2.12 and 2.13. We can always find a fractional (including improper fractions) interest rate such that the following generalization of 2.12 is appropriate:

$$
\begin{aligned}
(1 + i_p)^p &= (1+i)^q \\
\Rightarrow 1 + i_p &= (1+i)^{\frac{q}{p}} \\
\Rightarrow i_p &= (1+i)^{\frac{q}{p}} - 1
\end{aligned}
\qquad \textbf{(2B.16)}
$$

where p is the number of times that i_p is compounded in q years and it is assumed that i is the annual nominal interest rate. For example, if p = 12 and q = 1 we get equation 2.12.

Now consider an annuity that is paid at the end of each period with a final payment at some fraction of a period. Let n be a noninteger with int(n) representing the integer part of n and frac(n) the fractional part where n = int(n) + frac(n). Now assume a payment stream with present value at time zero of V_0. The annuity is defined implicitly by

$$
\frac{a}{(1+i)^1} + \frac{a}{(1+i)^2} + \cdots + \frac{a}{(1+i)^{\,int(n)}} + \frac{as}{(1+i)^n} = V_0 \qquad \textbf{(2B.17)}
$$

where "as" is a payment made at the termination point. The general formula for an annuity in equation 2B.9 implies that

$$
a = \frac{V_0}{\sum_{t=1}^{n} \frac{1}{(1+i)^t}} = \frac{V_0}{\left[\dfrac{1 - \dfrac{1}{(1+i)^n}}{i}\right]} = V_0 \left[\frac{i}{1 - (1+i)^{-n}}\right] = V_0 \, \frac{i(1+i)^n}{\left[(1+i)^n - 1\right]}. \qquad \textbf{(2B.18)}
$$

Now write out equation 2B.17 substituting for the summation from 2B.9 as follows:

$$
\begin{aligned}
& a \sum_{t=1}^{int(n)} \frac{1}{(1+i)^t} + \frac{as}{(1+i)^n} = V_0 \\
\Rightarrow\ & a \left[\frac{1 - (1+i)^{-int(n)}}{i}\right] + \frac{as}{(1+i)^n} = V_0 \\
\Rightarrow\ & a \left[\frac{(1+i)^{int(n)} - 1}{i(1+i)^{int(n)}}\right] + \frac{as}{(1+i)^n} = V_0 .
\end{aligned}
\qquad \textbf{(2B.19)}
$$

We can then solve 2B.19 for the fractional payment (as) as follows:

$$
\begin{aligned}
& a\left[\frac{1-(1+i)^{-int(n)}}{i}\right] + \frac{as}{(1+i)^n} = V_0 \\
\Rightarrow\ as &= (1+i)^n V_0 - (1+i)^n\, a\left[\frac{1-(1+i)^{-int(n)}}{i}\right] \\
&= (1+i)^n V_0 - a\left[\frac{(1+i)^n - (1+i)^{frac(n)}}{i}\right] \\
&= (1+i)^n V_0 - V_0\left[\frac{i}{1-(1+i)^{-n}}\right]\left[\frac{(1+i)^n - (1+i)^{frac(n)}}{i}\right] \\
&= V_0\left[\frac{(1-(1+i)^{-n})(1+i)^n - (1+i)^n + (1+i)^{frac(n)}}{1-(1+i)^{-n}}\right] \qquad \textbf{(2B.20)} \\
&= V_0\left[\frac{(1+i)^n - 1 - (1+i)^n + (1+i)^{frac(n)}}{1-(1+i)^{-n}}\right] \\
&= V_0\left[\frac{(1+i)^{frac(n)} - 1}{1-(1+i)^{-n}}\right] \\
&= \frac{1}{i}\, V_0\left[\frac{i}{1-(1+i)^{-n}}\right]\left[(1+i)^{frac(n)} - 1\right] \\
\Rightarrow\ as &= a\,\frac{[(1+i)^{frac(n)} - 1]}{i}.
\end{aligned}
$$

We can verify that this definition of the partial payment (as) is correct by substituting from 2B.20 into 2B.19 as follows:

$$
\begin{aligned}
& a\sum_{t=1}^{int(n)}\frac{1}{(1+i)^t} + \frac{a\left(\dfrac{(1+i)^{frac(n)}-1}{i}\right)}{(1+i)^n} = V_0 \qquad \textbf{(2B.21)} \\
\Rightarrow\ & a\left[\frac{1-(1+i)^{-int(n)}}{i}\right] + \frac{a\left((1+i)^{frac(n)}-1\right)}{i(1+i)^n} = V_0 .
\end{aligned}
$$

Now use 2B.18 to define V_0 as follows:

$$\begin{aligned} a &= V_0 \frac{i}{\left[1 - (1+i)^{-n}\right]} \\ \Rightarrow V_0 &= a\left(\frac{1-(1+i)^{-n}}{i}\right). \end{aligned} \tag{2B.22}$$

Then set 2B.21 and 2B.22 equal to each other and show that the left-hand side equals the right-hand side:

$$\begin{aligned} & a\left[\frac{1-(1+i)^{-int(n)}}{i}\right] + \frac{a\left((1+i)^{frac(n)}-1\right)}{i(1+i)^n} = a\left(\frac{1-(1+i)^{-n}}{i}\right) \\ \Rightarrow & \left[\frac{1-(1+i)^{-int(n)}}{i}\right] + \frac{\left((1+i)^{frac(n)}-1\right)}{i(1+i)^n} = \left(\frac{1-(1+i)^{-n}}{i}\right) \\ \Rightarrow & \left(\frac{(1+i)^n - (1+i)^{frac\,n} + (1+i)^{frac(n)} - 1}{i\,(1+i)^n}\right) = \left(\frac{1-(1+i)^{-n}}{i}\right) \\ & \qquad \Rightarrow \left(\frac{(1+i)^n - 1}{i\,(1+i)^n}\right) = \left(\frac{1-(1+i)^{-n}}{i}\right) = \left(\frac{(1+i)^n - 1}{i\,(1+i)^n}\right). \end{aligned} \tag{2B.23}$$

We can also find the fractional payment (as) using the equation 2B.16 and the definition of an annuity. First rewrite 2B.16 with $p = \frac{1}{\text{frac(n)}}$ and q = 1 as follows:

$$\begin{aligned} (1+i_f)^{\frac{1}{frac(n)}} &= (1+i) \\ \Rightarrow 1 + i_f &= (1+i)^{frac(n)} \\ \Rightarrow i_f &= (1+i)^{frac(n)} - 1 \end{aligned} \tag{2B.24}$$

where i_f is the interest rate that when compounded $\frac{1}{\text{frac(n)}}$ times per period is equivalent to the interest rate i compounded once per period. Now write the equation for V_0 (equation 2B.22) for two different annuities covering one period.

$$V_0 = a\left(\frac{1-(1+i)^{-1}}{i}\right) = as\left(\frac{1-(1+i_f)^{\frac{-1}{frac(n)}}}{i_f}\right). \tag{2B.25}$$

If we substitute the expressions in 2B.21 into 2B.22 we obtain

$$
\begin{aligned}
a\left(\frac{1 - (1 + i)^{-1}}{i}\right) &= as\left(\frac{1 - (1 + i_f)^{\frac{-1}{frac(n)}}}{i_f}\right) \\
&= as\left(\frac{1 - (1 + i)^{-1}}{(1+i)^{frac(n)} - 1}\right) \\
\Rightarrow \frac{a}{i} &= \frac{as}{(1+i)^{frac(n)} - 1} \\
\Rightarrow as &= a\left[\frac{(1+i)^{frac(n)} - 1}{i}\right]
\end{aligned}
\qquad \textbf{(2B.26)}
$$

which is the same as 2B.20.

APPENDIX 2C

Using Annuities to Represent the Costs of a Capital Asset: Example

As discussed in the body of Chapter 2, it is often useful to represent the variable cost stream associated with a capital asset over its lifetime using a constant annuity payment. The idea is to compute the net present value of all CARs associated with ownership and use of the asset and then construct an annual end-of-period annuity having the same present value. The example in the chapter considered costs associated with economic depreciation (service reduction and price changes) and opportunity interest cost but ignored maintenance, service enhancement, and other time costs. This is a common practice because the present value of economic depreciation and opportunity interest can be computed using the formula $\left(V_0 - \frac{V_n}{(1+i)^n}\right)$ where V_0 is initial value and V_n is the value at the end of n periods without having to consider the year-by-year cost/return flows. Economic depreciation (ED) in year t is given by the sum of service reduction and price change costs and is equal to $V_{t-1} - V_t$. Opportunity interest cost (OC) in year t is given by $(i)(V_{t-1})$. If we discount these terms back to the beginning of period 1 and then sum them for the n years we obtain

$$\begin{aligned} NPC(ED+OC)_0 &= \frac{V_0 - V_1 + iV_0}{(1+i)} + \frac{V_1 - V_2 + iV_1}{(1+i)^2} + \cdots + \frac{V_{n-1} - V_n + iV_{n-1}}{(1+i)^n} \\ &= \frac{V_0(1+i)}{(1+i)} - \frac{V_1}{(1+i)} + \frac{V_1(1+i)}{(1+i)^2} - \frac{V_2}{(1+i)^2} + \frac{V_2(1+i)}{(1+i)^3} - \frac{V_3}{(1+i)^3} + \cdots \\ &= V_0 - \frac{V_{n-1}}{(1+i)^{n-1}} + \frac{V_{n-1}(1+i)}{(1+i)^n} - \frac{V_n}{(1+i)^n} \\ &= \left(V_0 - \frac{V_n}{(1+i)^n}\right) \end{aligned} \tag{2C.1}$$

where $NPC(ED+OC)_0$ is the net present value of ED and opportunity cost at the end of period zero.

When other costs such as maintenance or service enhancement are considered, a year-by-year accounting is required to find the net present value. For an asset that is held n years, the net present value at the end of period 0 for the cost stream is given by

$$NPC_0 = \left(V_0 - \frac{V_n}{(1+i)^n}\right) + \sum_{t=0}^{n} \frac{C_t}{(1+i)^t} \tag{2C.2}$$

where NPC_0 is the present value of costs at the beginning of period 1, V_0 is the initial purchase cost, V_n is the salvage value at the end of the n^{th} year, C_t is expenses such as maintenance and taxes associated with the asset in period t, and i is the nominal interest rate. It is assumed that all costs in period t occur at the end of the period. These costs can be converted to an annual nominal annuity with n payments, one at the end of each year, by dividing equation 2C.2 by $US_0(i,n)$ as follows:

$$a^{nom} = \frac{\left[\left(V_0 - \frac{V_n}{(1+i)^n}\right) + \sum_{t=0}^{n} \frac{C_t}{(1+i)^t}\right]}{US_0(i,\, n)}$$

$$= \frac{\left[\left(V_0 - \frac{V_n}{(1+i)^n}\right) + \sum_{t=0}^{n} \frac{C_t}{(1+i)^t}\right]}{\left(\frac{1 - \frac{1}{(1+i)^n}}{i}\right)}. \qquad \textbf{(2C.3)}$$

A real annuity could be constructed in a similar manner.

Consider now an example similar to the one in the body of Chapter 2 where a tractor with 1,500 hours of useful life is purchased at the beginning of the first period for $30,000 or $20.00 per hour of potential service. The tractor is assumed to be used for 250 hours each year. Based on this purchase price and 250 annual hours of use, the real value of maintenance at the end of each year is assumed to follow the pattern in Table 2C.1. This maintenance cost will be larger with inflation. This pattern assumes that a tractor with fewer remaining hours of service will have higher maintenance costs. For purposes of this example, assume that the maintenance will take place at midyear rather than at the end of the year so that interest will accrue during the year at a rate of $(1+i)^{.5}$. The property tax rate is assumed to be 1% of market value at the beginning of the period, but paid at the end of the period. The producer is planning on some major service enhancement at the end of the third period to restore 250 hours worth of service potential. Maintenance will change after the service enhancement because the tractor will now have a longer service life. Specifically, the real value of maintenance in period 4 will be the same as in period 3.

TABLE 2C.1 Data on Purchase, Use, and Sale of Tractor

Item	
Initial service capacity (hours)	1,500.00
Real price of 1 hour of service potential in period 1	$20.00
Initial purchase price (V_0)	$30,000.00
Use per year (hours)	250.00
Service enhancement at end of period 3 (hours)	250.00
Property tax rate	.01
Real interest rate	.04
Inflation rate	.05
Implied nominal interest rate	.092

Real value of maintenance performed at end of period t based on cumulative hours of use and list price in current dollars

Year	Maintenance Cost	Cumulative Use	Inflated List Price
1	$75.00	250	31,500
2	$225.00	500	33,075
3	$375.00	750	34,728.75
4	$525.00	1,000	36,465.108
5	$675.00	1,250	38,288.447

Table 2C.2 is similar to Table 2.12 in Chapter 2 and documents the costs for this tractor for each of the five years, the present value of these costs, and the equivalent annual nominal and real annuities. Consider the first year. Based on a purchase price of $30,000, the opportunity cost is given by ($30,000)(.092) = $2,760. The decline in service capacity of 250 hours valued at beginning-of-year prices of 20 dollars per hour gives a cost of (250)($20) = $5,000. The end of the year service capacity is 1,250 hours. With 5% inflation, the price of a unit of service at the end of the period is 21 dollars. The price change cost is then [($20-$21)(1,250)] = -$1,250. The sum of service reduction and price change costs is equal to economic depreciation and given by ($5,000 - $1,250) = $3,750. The value of the tractor at the end of the year is ($21)(1,250) = $26,250. Economic depreciation can also be computed as V_0 - V_1, which gives ($30,000 - $26,250) = $3,750 as before. With 5% inflation the real end-of-period value of the maintenance must be adjusted upwards to $78.75 [($75)(1.05)]. Because the producer is incurring this expense at midyear rather than at the end, we must account for the earlier commitment of funds. The end-of-period cost is then ($78.75)$(1.092)^{.5}$ = $82.29. With property taxes of $300, total costs for the period are $6,892.29 ($2,760+5,000-$1,250+$82.29+$300).

Computations for the second year are similar to the first. For example, service reduction is given by ($21)(250) = $5,250. Given 5% inflation, maintenance costs paid at the end of period 2 would have value ($225)$(1.05)^2$ = $248.06. Given that they must be paid at midyear, the cost is ($248.06)$(1.092)^{.5}$ = $259.22.

Opportunity costs of $2,415 can be divided into inflation costs of $1,312.50 [($26,250)(.05)] and real interest costs of $1,102.5 [(1.05)($26,250)(.04)]. The property tax is computed as 1% of $26,250 or $262.5.

The third year is somewhat different because service enhancement takes place. The price of an hour of service at the end of the third year is $23.1525 [($20)$(1.05)^3$]. The cost of restoring 250 hours of service at the end of the year is assumed to be (250)($23.1525) = $5,788.125. This enhancement will restore the tractors service life to 1,000 hours. Maintenance paid at year's end would be ($375)$(1.05)^3$ = $434.11 and with interest for one-half year is ($434.11)$(1.092)^{.5}$ = $453.64. There is no charge for service reduction because the beginning and end-of-year service capacities are the same after the service enhancement. Specifically, the tractor has 1,000 hours of service at the beginning and end of the year which at beginning and ending prices of $22.05 and $23.1525 give values of $22,050 and $23,152.5. Notice that the value of the tractor at the end of the year is just the value at the beginning adjusted for inflation [$23,152.5 = (1.05)($22,050)]. Property taxes are ($22,050)(.01) = $220.50. Total costs for the year are $7,388.36.

Computations for the fourth and fifth years are similar. Maintenance in the fourth year is just the maintenance value for the third year ($434.109) adjusted for an inflation rate of 5% because the tractor has the same remaining service life for both years. Specifically, $453.6391 = ($434.109)(1.05). The present value of all the annual costs at the beginning of period 1 (end of period 0) is given by discounting each to the beginning of period 1 using the nominal interest rate of 9.2%. This discounted sum is $28,597.151. This can be converted to a nominal annuity by dividing it by $US_0(9.2, 5)$ or to a real annuity using $US_0(4.0, 5)$. The nominal annuity is $7,390.304 and the real annuity is $6,423.6955. This real annuity would be multiplied by the (1+p) to adjust for inflation in the first period. The inflation-adjusted annuity is then (6,423.69)(1.05) = $6,744.8803.

TABLE 2C.2 Annuities and Multiperiod Costs Including Service Enhancement, Maintenance, and Taxes

Annual real interest	0.04
Original life of asset	1,500
Salvage life (assuming no enhancement)	250
Life in years	5
Annual depreciation	250
Initial price	20
Property tax rate	0.01

Year	Inflation Rate	Nominal i	Service Enhancement (hrs)
1	0.05	0.092	0
2	0.05	0.092	0
3	0.05	0.092	250
4	0.05	0.092	0
5	0.05	0.092	0

Nominal Annuity including Maintenance	7,390.304
Real Annuity incl Maintenance	6,423.695
Nominal Annuity for Maintenance	$368.78
Real Annuity for Maintenance	$320.55

Year	Item	Beg. Price	Beg. Quantity	Actual Value	Direct Cost	Opp. Cost	Inflation	Interest	Total Use Before Enhanced	Total Use After Enhanced	End Price	End Quantity	End Value	Cost
1	Investment	20	1,500	30,000	0	2,760	1,500	1,260	250	250	21	1,250	26,250	2,760
	Service enhancement													0
	Service reduction													5,000
	Maintenance			78.75	78.75	3.542808	1.94474	1.5981						82.29281
	Price change													-1,250
	Property taxes													300
	Total													6,892.293
	Constant nominal annuity													7,390.304
	Infla. adj. real annuity													6,744.88
2	Investment	21	1,250	26,250	0	2,415	1,312.5	1,102.5	500	500	22.05	1,000	22,050	2,415
	Service enhancement													0
	Service reduction													5,250
	Maintenance			248.0625	248.06	11.15985	6.12592	5.0339						259.2223
	Price change													-1,050
	Property taxes													262.5
	Total													7,136.722
	Constant nominal annuity													7,390.304
	Infla. adj. real annuity													7,082.124

TABLE 2C.2 (continued)

	Item	Beg. Price	Beg. Quantity	Actual Value	Direct Cost	Opp. Cost	Inflation	Interest	Total Use Before Enhanced	Total Use After Enhanced	End Price	End Quantity	End Value	Cost
3	Investment	22.05	1,000	22,050	0	2,028.6	1,102.5	926.1	750	500	23.15	1,000	23,152.5	2,028.6
	Service enhancement													5,788.125
	Service reduction													0
	Maintenance			434.10938	434.11	19.52973	10.7204	8.8094						453.6391
	Price change													-1,102.5
	Property taxes													220.5
	Total													7,388.364
	Constant nominal annuity													7,390.304
	Infla. adj. real annuity													7,436.231
4	Investment	23.1525	1,000	23,152.5	0	2,130.03	1,157.63	972.41	750	750	24.31	750	18,232.59	2,130.03
	Service enhancement													0
	Service reduction													5,788.125
	Maintenance			455.81484	455.81	20.50622	11.2564	9.2498						476.3211
	Price change													-868.219
	Property taxes													231.525
	Total													7,757.782
	Constant nominal annuity													7,390.304
	Infla. adj. real annuity													7,808.042
5	Investment	24.3101	750	18,232.594	0	16,77.399	911.63	765.77	1,000	1,000	25.53	500	12,762.82	1,677.399
	Service enhancement													0
	Service reduction													6,077.531
	Maintenance			670.04782	670.05	30.14414	16.5469	13.597						700.192
	Price change													-607.753
	Property taxes													182.3259
	Total													8,029.695
	Constant nominal annuity													7,390.304
	Infla. adj. real annuity													8,198.444

TABLE 2C.2 (continued)

	Value	Cost
US_0 Real	4.4518223	
US_0 Nominal	3.8695501	
P.V. of total annual costs (end of period 1)		31,228.09
P.V. of total annual costs (beg. of per. 1)		28,597.15
P.V. of nominal annuity (beg. of 1)		31,228.09
P.V. of inflation adjusted-real annuity (beg. of 1)		31,228.09
P.V. of maintenance (end of period 1)		1,558.297
P.V. of maintenance (beg. of period 1)		1,427.012
P.V. of nominal annuity less mnt. (beg. of 1)		29,801.08
P.V. of inflation adjusted-real annuity less mnt. (beg. of 1)		29,801.08

CHAPTER 3

REVENUES AND GOVERNMENT PROGRAMS PARTICIPATION

INTRODUCTION

This chapter discusses issues, procedures, and recommendations for calculating the return elements of cost and return (CAR) estimates. Returns consist of revenues from the sale of agricultural products, government program receipts, and other miscellaneous revenues. The issues are discussed within four major sections: (1) Outputs of Production, (2) Pricing of Outputs, (3) Government Program Receipts, and (4) Miscellaneous Revenues.

In principle, revenue is simply price received multiplied by the quantity for the output of a farming activity, i.e.,

$$R = PQ, \qquad \textbf{(3.1)}$$

where R is estimated revenue, P is the price of the commodity produced, and Q is the quantity of the commodity produced. In reality, estimating revenue is much more complex when the wide range of commodity production systems and marketing alternatives associated with agricultural production is considered. For example, accounting for joint or by-products, variations in product quality, and government policy toward agriculture are some of the sources of complexity.

When multiple products and other complexities are introduced, the revenue equation becomes

$$R = \sum_j P_j Q_j + VBP + GP + ARV \qquad \textbf{(3.2)}$$

where P_j is the price for the quality differentiated commodity j, Q_j is the quantity of commodity j, VBP is the value of salable joint or by-products, GP are direct government payments, and ARV are associated revenues such as patronage rebates and dividends, crop insurance receipts, and market pool returns spread over time.

Prices and quantities used in revenue calculations are influenced by such factors as the quality or quantity of output, the location and timing of sale or production, and the structure of the market. These components should be specified with as much detail as possible.

> **Example:** The price used in a revenue equation should correspond to the yield/quality component. For example, it should be clear whether the wheat price used in the CAR estimate is for a particular class of wheat or for an average of all classes. The CAR should

specify whether the price for hard red spring wheat is for 12% or 14% protein. And the CAR should clarify whether the yield is the field run or paid yield.

An underlying consideration in developing revenues for CAR estimates is that there should be correspondence between the revenues and costs as well as between the price and yield used to generate the revenues. Correspondence must occur in at least three ways. First, prices for produced commodities must correspond to the time and location at which either ownership of the commodities is transferred from the grower or the commodity is used in another enterprise. Second, the units of the prices and yields must correspond. For example, if vegetables are harvested and marketed on a per box basis, then prices should also be on a per box basis. Third, prices must reflect, in so far as possible, the quality of the commodity sold. For example, cotton grown in California is on average of higher quality than cotton grown in the nation as a whole. Thus, cotton prices should be used which reflect the higher quality of production.

It is important to specify the point in the production-marketing process at which quantities and prices are determined. Typically, CAR estimates are prepared for the production process, but the point at which production ends and marketing begins is not always obvious. For many farmers, marketing begins at the point a commodity moves into on-farm or off-farm storage. In some situations, the product may be produced in one calendar year and stored into the next calendar year, with the costs of storage and sale being the only costs incurred after harvest. Alternatively, some other demarcation line between the production stage and the marketing stage may be defined. Some commodities may be priced standing (e.g., alfalfa hay or timber sold on the stump), but others may be priced on a consumer-ready basis. Some commodities may be field packed and others shed packed leading to different yields and prices. For these commodities, "value added" is a part of the production process (e.g., field boxing of lettuce and onions). A stage wherein an actual price and quantity exists should be chosen as the demarcation line between the production and the marketing stages. In any case, the additional functions that must be performed to maintain the correspondence between the cost side and the revenue side of the budget must be included in the CAR estimate.

The Task Force recommends that commodity yields and prices be estimated at the end of the production period, or the point in the production-marketing process at which the commodity leaves the ownership of the grower, whichever is more appropriate for the purpose of the analysis. If an alternative point is chosen, it is essential that the point be specified clearly, that the time period represented by costs matches the time period reflected in returns, and that all values be adjusted to this reference time point.

The revenue calculations in equations 3.1 and 3.2 are for a single enterprise or production activity, e.g., growing corn or feeding hogs. The calculations may account for multiple outputs and multiple qualities. The costs and revenues of such activities can be calculated for the farm or ranch as a whole or they can be calculated for some technical unit of production, e.g., acre, head, or some other appropriate base. Traditionally, CAR estimates for agricultural activities have been prepared per unit of land (acre or hectare) or animal units (head or pound) while other nonagricultural production activities are estimated per unit of labor and/or capital. The discussions throughout this section refer to CAR estimates for a technical production unit. Each component of the revenue equation is examined in the following sections.

OUTPUTS OF PRODUCTION

Output is measured in physical production or output units as the quantity of a commodity produced over the production period (i.e., bushels, pounds, hundredweight, tons, head, liters, kilograms, etc.) and is a function of the physical and financial resources available to producers and the decisions made by producers as to how to combine these resources. Cost and return estimates should specify the quantity and quality of available resources (for projected CAR) or the actual resources used (for historical CAR). Several issues that arise in the calculation of output for CAR estimates are listed below.

- The technical production unit must be appropriately identified for the production activity.
- The location and regional aggregation in determining the quantity of output produced by a production activity must be considered.
- Quality and quality aggregation should be accounted for if commodities are differentiated on the basis of grade.
- The role of input and management levels in determining outputs should be identified.
- Differences in output under alternative production activities (technical differences) should be recognized.
- Relationships between commodity output or yields and commodity prices should be stated.
- Uncertainty should be addressed in estimating output measures.
- Jointness in output may exist and should be handled appropriately.
- Alternative data sources should be incorporated, if appropriate.

Each issue is discussed briefly in the following paragraphs.

Technical Production Unit

Revenue in a CAR estimate is calculated on a technical production unit basis. For crops, this production unit is generally per unit of land (i.e., acre or hectare) and for livestock, the standard unit is generally per head. However, the issue is not always clear. For example, should crop CAR estimates be defined in terms of an acre of land or a ton of output? Should feeding enterprise CAR estimates be based on head of feeder animals purchased or head of market animals sold? One point is clear: the relative costs and returns in the estimate should not be affected by the selection of the basic unit. For example, if the cost of feeder animals equals 40% of the income from a feeding enterprise, it will remain 40% of income regardless of whether the production unit is 100 pounds of animal sold or per head sold.

The basic technical production unit selected usually represents a major resource constraint managers face in planning the business. Choosing a common resource as the basis for the technical production unit facilitates the comparison of costs and returns across alternative enterprises. For example, a manager planning crop production must allocate land among the crops to be produced, making acre or hectare a reasonable basic technical production unit to use for planning. By comparing CARs per acre of different crops, the manager can make an economic choice. In this example, a unit of one of the inputs, land, has been selected as the basic unit. For livestock feeding operations, capacity may be measured in terms of the number of head of finishing livestock that can be handled in the manager's facilities. In "all in, all out" facilities, that capacity is defined by the number of market weight animals that the facilities can accommodate. Costs and returns may be measured in terms of head sold in this case. In the case of a cattle feedlot, a manager may consider the returns per year from finishing yearling cattle versus feeder calves in a lot with fixed capacity.

Ideally, CAR estimates for a commodity should be easily comparable to prices quoted for that commodity. For example, if live hog prices are quoted in dollars per hundred pounds liveweight, then the weight of hogs purchased and sold by the enterprise should be listed on the CAR estimate in hundred pounds liveweight.

As described previously, the output per technical production unit (acre or head) is called yield whether discussing crops or livestock. The specification of the technical production unit affects both costs and revenues. Therefore, it is important that the technical production unit used as the basis for CARs be identified clearly. For crops, this means indicating whether the acre is a "planted acre" or a "harvested acre."

The Task Force recommends that CAR estimates for crops be done on a planted acre basis. Keeping revenue and cost calculations on a planted acre basis incorporates acreage not in production, but needed for that particular production system.

Example: Government policy in the United States has often required set-aside acreage for certain farm program crops in the U.S. The cost of maintaining set-aside acreage should be proportionally allocated to the planted acre. Thus a farmer producing corn who sets aside 10% of the base acreage to qualify for government program participation would have a technical unit or "planted acre" that is composed of 1.0 acre of corn and 0.11 acre of set aside. The proportion that is planted and the proportion set aside should be clearly specified. Yields are calculated on a planted acre basis.

Example: The summer fallow acreage in a winter wheat–spring barley–summer fallow rotation changes the basis of the production activity. For crop rotations that include summer fallow, the cost of summer fallow is allocated to the crop or crops actually planted. Costs may be allocated equally to each crop or allocated on the basis of value with the crop receiving the majority of the benefit having a higher pro-rata share. In either case, it is important to document the assumption. Yields are again calculated on a planted acre basis.

For perennial crops like orchards and vineyards with long nonproductive establishment periods, the CAR estimate should indicate the basis on which the acre is defined—preproduction acre, a partially producing acre, a fully productive acre—or some other basis.

A similar situation exists for many types of livestock production. Cost and return estimates can be prepared for a specified segment of the production cycle, or they may represent the entire cycle averaged across the herd.

Example: The technical production unit for the dairy herd can be a cow in the herd including the raising of replacement heifers. Alternatively, the cost of raising dairy heifer replacements can be separated from the dairy production CAR estimate. In this case, the cow in the herd and the replacement heifer (ready to enter the herd) may be the technical production units for the two CAR estimates.

Example: An area that generates some confusion is livestock grazing where output is often based on a per head or per pound basis, i.e., 50 calves are sold at $100 per calf although many costs are calculated on an Animal Unit Month (AUM) basis.[1] Cost and return estimates can be reconciled on either basis. Again, it is important to document the procedure used.

Yield: Quantity, Quality, and Aggregation

Yield is measured in quantitative amounts and qualitative characteristics. It is particularly important to note the qualitative characteristics that influence the market price of the product. Yield has both an expected component and a variable or stochastic component.

The expected component of quantitative yield can be estimated as an average using historic production records for the farm or region for which the CAR estimate is being determined. The level of enterprise definition, described previously, is essential in the final determination of such a yield estimate.

For enterprises new to the farm or area, estimates can be made by examining the records of similar farms in the area or by using research data. In both cases, care must be taken to estimate yields appropriate to the levels of planned inputs and adjusted for potential changes in growing conditions.

The expected component of the qualitative characteristics of yield can also be estimated from historic records as the average for the farm or area as appropriate for the level of inputs used in the production process. Consideration of the qualitative characteristics of yield varies among commodities. Quality-differentiated yield is of particular importance in cotton, malt barley, seed crops, livestock, vegetables, and fruit production. Clear specification of yield quality should accompany CAR estimates because yield quality affects a commodity's marketability and, therefore, its ultimate price.

Published yield information is often aggregated across all qualities. Such aggregations are, in many cases, sufficient if they correspond to the aggregation of prices for which the commodity is sold. For some commodities, differences in quality pricing are established from a fixed schedule. However, variations from the schedule may exist if supply and demand imbalances exist at specific qualities.

The Role of Inputs and Management Levels

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[1] An Animal Unit Month is the forage required to sustain one mature cow and suckling calf or equivalent for one month. See Table 4.1 for animal unit equivalents for animals of different sizes and species.

Production yield should be consistent with production technologies in the area for which the estimate is being made and for the levels of input being used. If an average technology and management set is assumed for the CAR estimate, an average output level may be appropriate, especially in examining historic CAR estimates. However, the level of assumed inputs (which defines the technology/management mix) also affects the level and quality of the output. Again, it is important to document the assumptions in the notes to the CAR estimates. In many cases it is appropriate to prepare alternative estimates of CARs based on different input and corresponding output levels. For example, it may be appropriate to prepare a projected cost of production and revenue based on shallow sloping soils with one level of fertilization and a different projected set of CARs based on bottom land with an alternative level of fertilization and expected yield.

Production Systems

Factors that affect production should be identified clearly. This generally means being as specific as possible when identifying the commodities produced and the production practices used by an enterprise. Any factor that allows the commodity to be differentiated according to price should be included. This includes such factors as class, variety, grade, and location. Projected CAR estimates are often made using alternative technologies for which different sets of inputs are considered. These estimates are based on projected or hypothesized production systems. In such cases, yield calculations may be based on research information and yields obtained with related production systems. Yields are usually estimated by adjusting existing information to reflect the changes in technologies. Care should be taken to identify the data used and the adjustments made.

Relationships Between Commodity Yields and Commodity Prices

In some situations, crop yield and quality are highly related to output price, i.e., if prices are low, yields also are low; and if prices are high, yields are high (and the average quality of the harvest is usually lower). This relationship is particularly evident for fresh vegetables or fruit which is priced on a daily basis. As total supplies become low and prices for the commodity rise, growers harvest more of the produce and a larger proportion of the produce is of lesser quality.

> **Example:** The price of fresh packed lettuce is highly volatile in most growing seasons. In the short term, a supply shortage created by bad weather or insect outbreaks causes a rapid increase in price. Responding to the price increase growers harvest as much lettuce as possible. When prices are low, growers harvest the quantity necessary to meet contracted obligations but they tend to harvest the crop more slowly in an effort to maximize net revenue.

In preparing historical CAR estimates it is important to use yields and prices that are mutually compatible. For example, if the majority of the crop from a given farm or region was sold during a period of high seasonal prices and low seasonal quality, an annual season average price would not be appropriate. In preparing projected estimates, yield assumptions should be consistent with assumed prices. For example, in preparing long-run cost projections based on assumed technological progress and yield enhancements, the potential impact on market prices should be acknowledged in projecting associated revenues.

Yield Quantity and Quality Variability

"Unexpected events," such as drought, timely rains, pest infestations, diseases and other events also influence (positively or negatively) both quantity and quality of yield. Thus, actual or observed yield varies in both quantity and quality. Producers plan for and attempt to control the expected component of production, while the stochastic component results from situations or events over which producers have little or no control. For many CAR uses, estimates of revenue variability may be important.

In addition to the point estimate describing yield in terms of both quantity and quality, the variability of each should also be recognized. Variability estimates can be derived by using standard statistical procedures, if time series of historic data or cross-sectional experimental data are available. Alternatively, subjective estimates can be elicited from producers when relevant historical data are not available. The end-use of the CAR estimate and the available data determine which procedures are appropriate.

One method of dealing with both yield and price variability is to include a sensitivity analysis of changes to price and yield in the CAR estimate. Simply combining the measures of yield and price variability to determine extreme ranges of possible revenue should be avoided and appropriate statistical procedures that consider the correlation of yield and price should be used. (For a more complete discussion of these issues, see Boehlje and Eidman: Ch. 11.)

Harvested Yield and Marketable Yield

For products that are stored on the farm, there may be storage losses so that the yield harvested is not equal to the yield actually marketed. Bushels of corn after drying may be less than bushels of corn before drying. Another example is kiwi where the fruit is repacked throughout the year in storage and the shrink increases over time. Thus the harvest cost is for a yield higher than the marketed yield. For fresh market fruit, the farmer may pay to harvest all of the fruit, but only market that portion of the fruit that makes grade. Also, the units of measure are often different for harvest and sale. For example, for oranges, the contract harvest is for 500 pound boxes. The oranges are sorted and 70% go into 37.5 pound boxes for sale and the rest go to juice. The price received for juice is per pound, the price for oranges is per 37.5 pound box and the harvest cost is per 500 pound box. Such differences must be carefully noted and accounted for in preparing estimates.

Multiproduct Production and Joint Products

In many agricultural production activities, more than one product or commodity is produced. Jointness refers to the technical interdependence between several outputs from the same production activity. This interdependence is commonly classified for a single allocable factor as complementary, competing, or independent, depending on the change in marginal productivity[2] with a change in the alternative products. The interdependence between outputs is complementary when increasing the output of one product increases the output of the other product(s); it is competitive when increasing the output of one of two or more products decreases the output of the other(s); or the interdependence is supplementary, or the products are independent, when increasing the output of one product has no effect on the output of the other product(s). The competitive case is probably the most common.

With many multiple output technologies, one of the products is often considered primary with the other products considered either secondary or by-products. All products are included in the revenue calculation unless they are not to be marketed. For most cases, yield and price estimates can be made independently for each commodity and estimated revenues simply added together. In some cases, where one or more commodities are not directly marketed or for which yields are not directly estimated, additional consideration must be used.

In computing costs of production per output unit as compared to production unit, there is often some question as to how to handle the revenue from secondary products. A classic example is the cost of producing a cwt of milk. Because the dairy enterprise also produces calves and cull cows, the question arises as to whether these revenues should be netted out in estimating the cost of milk per cwt. In the dairy farm example from Chapter 13 (Table 13.3), the total cost per dairy cow is $2,686.80. This dairy cow produces 216 cwt of milk per year. This gives a cost per cwt of $13.04. The dairy cow also produces bull and heifer calves with gross returns of $51.00 and $61.20 respectively. If these other revenues are subtracted from total costs (ignoring implicit interest for now), the net cost of the milk is $2,574.6. This gives a price per cwt of $11.92 (2,574.6/216). This is a difference of $1.12 per cwt. This difference may be important for dairy policy. While one estimate or the other may be more appropriate in a given situation, it is important for the analyst to make clear exactly how the cost per cwt or bushel was computed. Numerous cases like this arise in practical estimation situations. Four more are discussed here.

> **Example:** Barley produces both grain and straw. The straw may or may not be a marketable product. The CAR estimate may be for barley grain only, or it may be for barley grain and straw. To achieve correspondence between revenues and costs, if the straw revenue is included, all costs associated with preparing the straw for sale should also be included in the CAR. In computing a cost per bushel for barley, one must decide whether to subtract the straw revenue from the total per acre cost of production. If such an adjustment is made, then the cost of barley production depends on the price of straw.

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[2] With a single allocable factor, technical interdependence between two products is commonly described in terms of a shift in marginal productivity. However, description of product interrelationships with two or more allocable factors is not possible because the signs of the relevant partial derivatives may differ. Technical product interdependence can be classified for the multiproduct case from the multiproduct cost function. Two products are said to be competitive, independent (supplementary), or complementary, if the marginal cost of producing one product is increased, unchanged, or decreased, respectively, as the level of the other product is increased. See Beattie and Taylor, pp. 209-210, for a more complete discussion.

Example: Two products can be identified in the production of cotton. Cotton lint and cottonseed (joint products) are considered primary and secondary complementary products, respectively. They cannot be produced separately although the proportions can change slightly depending on growing conditions and the variety of cotton produced. In such a case a cost per pound of cotton lint cannot be estimated independent of the quantity, quality and price of cotton seed produced.

Example: Three products can be identified in the production of apples. Fresh apples, apple sauce and apple juice can all be produced from trees in the same operation. The proportion of apples going to a given use may change depending on prices, yields, weather conditions, and product quality. If apples from a given portion of the operation all go to one use and the costs of production can be segregated, it may be possible to divide the enterprise.

Example: A product like alfalfa which has multiple harvests within a given production year may vary in quality and thus price between harvests. These differences should be accounted for in estimating revenues. Similarly a larger yield may lead to higher harvesting or hauling costs.

Although allocating revenues among joint products is rather straightforward, allocating costs is not always as simple. The allocation of cost to joint products is discussed in Chapter 4; a general discussion of joint products is contained in Chapter 9.

Data Sources for Determining Yields

Four basic sources of data are available to estimate yields for CARs. These are farm-level data; survey data collected at the county, state, or federal level; technical research data; and forecast models.

Farm-Level Data

Farm-level data on yield can be obtained from the farmer's memory and/or record keeping system. Of course, the accuracy of estimates is improved as verification of data increases. Another popular source of data is record keeping systems maintained by some universities and record keeping associations for improving farmer decision making. These records provide substantial information on individual farms, including yields and aggregation of farm data to regional or state levels. Variability measures are often made from historic time series data or from data from numerous farms in cross-section.

State/Federal Data

The National Agricultural Statistics Survey (NASS) and the Economic Research Service (ERS) of the United States Department of Agriculture (USDA) conduct large probability surveys to obtain yield and production levels, as well as other data, for most agricultural commodities. NASS maintains state offices and the state–federal offices conduct periodic (typically quarterly, but the frequency varies somewhat by the crop, livestock, or poultry enterprise and its importance in the state) surveys to obtain data on the number of units (acres, head, etc.) produced and the yield per unit. These data provide average yields at the state and county levels for many commodities. These statistics are rarely available at levels of aggregation below the county level. ERS conducts the Agricultural Resource Management Study (ARMS) (formerly called the Farm Cost and Return Survey) for several commodities each year, with the commodities surveyed varying from year to year. The ARMS, discussed further in Chapter 12, develops yield data for producing regions that cross state lines. It also provides average yields by state when the sample size permits.

Other federal, state, and local agencies provide data on agricultural production activities. For example, both the U.S. Bureau of Reclamation and numerous irrigation districts make estimates of production and yields for irrigation districts in the western states. Quality data are often available from other federal sources such as the Agricultural Marketing Service and individual state inspection services.

Marketing Associations, Cooperatives, and Private Dealers

Like farm-level data, the yield data from marketing associations and cooperatives may offer a measure of actual performance of a farm or a group of farmers. Private dealers and even specialized media sources may be a source of specific data. For example, cut-out data on a particular cross-breed of cattle may only be available from packers, producer marketing associations, order buyers or specialized farm newspapers.

Researchers, Forecasters, and Forecast Models

Technically-based research by universities, federal and state agencies, and private firms also provides important data for developing yield estimates. These data are especially useful for making estimates under alternative assumptions for planning and policy analysis. Such data are usually based on controlled field trials with fixed inputs and management that must be carefully examined when preparing the CAR estimate. Average yields and variability are commonly computed by the originating researchers.

Historical yield data often are extended into the future using various types of forecast models that range from simple trend analysis to econometric estimation. These data are also important in projecting the revenue for CAR estimates used for planning and policy analysis purposes. Such projections often provide a range of confidence for the forecast as a measure of potential variability. Which of these sources is appropriate depends on the expected use of the CAR. The data source used to derive the yield component should be specified in all CAR estimates. Any adjustments made to the data set should also be mentioned.

> **Example:** If the projected CAR is based on a five-year average yield for a given county where a severe drought reduced yields in the third year, that year might be removed if the probability of another serious drought is considered to be much less than 0.20. If this adjustment is made, it should be noted in the printed CAR estimate.

Recommendations for Estimating Outputs

The Task Force recommends that yield estimates for CAR calculations include all commodities produced and should include for each commodity the following components:

1. ***a description of the CAR assumptions and data sources that affect yields;***
2. ***an estimate of the expected quantitative yield and an estimate of the variability of that yield;***
3. ***an estimate of the expected qualitative yield and an estimate of the variability of that yield; and***
4. ***an estimate of the marketable portion of the yield.***

Methods of measuring yield vary with the intended use of the data. At the appropriate level of aggregation, all four sources can be used to prepare projected CARs. Yields for joint products can usually be made independently. Historical CARs can be based on farm level survey data to obtain the actual yield for the historic period. Variability can be presented in the form of ranges, coefficients of variation, sensitivity analysis, and so forth. For example, a soybean CAR estimate could include net returns for low, medium, and high yields based on historic data available on yields given alternative weather patterns.

PRICING OF OUTPUT

The price must correspond to the quality and other characteristics of the product in order to calculate revenue correctly. There are several dimensions to this correspondence: the time frame for commodity sales, the quality of the commodity sold, the regional differentiation of the product, and the location of the sales transaction. Price should also reflect the traditional or expected marketing practice for the commodity.

Costs and revenues should be compared in a common time frame to be valid. **The end of the production period is the recommended time period to compare all costs and revenues.** However, many commodities are harvested over several months and have no single harvest month. The appropriate method of compounding/discounting revenues to a common point in time is discussed in Chapter 2. The recommendation to adjust all revenues to a given harvest month or end of the year does *not* imply that a harvest month or end of year price should always be used. The price at which the product was sold (or is expected to be sold), adjusted to a common time point, is the appropriate price.

The market price of many commodities is determined by their intrinsic quality or grade. Price differences are observed in markets in the form of penalties or premiums received for different qualities of the commodity. In addition, some commodities receive a premium because they can be differentiated from similar commodities according to variety, the location in which they are grown, or, in some cases, by the technology used to produce a commodity.

> **Example:** Idaho potatoes and Washington apples are examples of regionally differentiated commodities. Organically produced commodities often receive a price premium.

Output prices should reflect market prices expected (for projected CAR) or actually received (for historic CAR) whether the products are sold in a market, transferred internally within the farm, or transferred to a landlord as share rent. Generally, CAR estimates should have a single price for each part of the output marketed in a different way or at a different point in time.

Selecting the Point in Time for Pricing the Commodity

It is important to specify the point in the production-marketing process at which the commodity is priced. This should be consistent with the point at which the marketable yield is determined. If value is added during a storage or packing process, the additional functions that must be performed to maintain the correspondence between the cost side and the revenue side of the budget must be included in the CAR estimate.

> **Examples:** Cotton is ginned as a part of the production process and is marketed as bales of lint and tons of cottonseed after ginning. In contrast, some vegetable and fruit farms utilize "U-pick" activities on the farm to sell products. Production on such farms is completed at the incidence of harvest by a nonpaid consumer/harvester who would remove the commodity from the farm. A consistent way to price the commodity in both cases is to record the price received when the grower sells the commodity.

As mentioned in the introduction to this chapter, the Task Force recommends that commodities be priced at the end of the production period, or the point in the production-marketing process at which the commodity leaves the ownership of the grower, whichever is more appropriate for the purpose of the analysis. The method and data used for such pricing depend to a great extent on the quality, the region, the season, and the timing of the assumed transaction. A brief description of each of these components follows.

Regional Prices

State or regional price estimates for many commodities on a historic basis are available from NASS and various state Agricultural Statistics Services. These data are aggregations (averages) derived from data initially observed by exact location and quality. The pricing method, observation period, and accuracy of estimate are usually discussed in the publication presenting the price series. Usually, obtaining prices differentiated by region, quality, or timing simply requires selecting the appropriate estimate from published series. If circumstances unique to the CAR estimate do not allow published price series to be used, weighted average prices over the expected qualities, times, or markets can be used to derive single prices.

Quality Differentials

Published price series are often aggregated over many different qualities of the commodity and many different times of delivery. Many CAR estimates are prepared for quality differentiated commodities, requiring a quality-specific price. Data for such differentiation must be found from sources other than the NASS series.

> **Example:** California cotton is recognized in all domestic and international markets to be, on the average, of higher grades and staples than cotton from the High Plains growing areas of Texas and Oklahoma. When developing a CAR for California cotton production, a California aggregation should include a weighting of prices at these higher qualities.

Seasonal Price

Many commodities have a seasonal price pattern. This seasonal pattern should be considered in developing appropriate prices for the month during which the commodity is sold by the grower. Special marketing arrangements may mandate a seasonal marketing pattern, requiring that a different price be estimated for each month in which some of the commodity is used. The appropriate storage and marketing costs should be included in the cost portion of the CAR estimate for the seasonal marketing pattern.

Identifying the precise point in time at which the commodity is priced may be particularly important for some perishable commodities. Growers in various regions of the world compete for markets based on seasonal prices of fresh commodities. Marketing windows are sought and utilized actively in production planning. Harvest times are critical for the economic success of such activities.

> **Example:** Fresh iceberg lettuce is grown in the winter in Southern California and Arizona when other parts of the country are unable to grow fresh produce because of adverse climate. Hence, it often commands a substantial premium price. Profits are often made and lost in windows of opportunity as small as one week.

The aggregation of prices over various time periods should be appropriate to the CAR being estimated. The potential for variable prices should also be noted in a CAR estimate. Fresh commodity prices can vary widely from week to week, day to day, and even within one day.

Multiproduct Production and Joint Products

Commodities that are usually produced as joint products should be priced as separate commodities when it is feasible to do so.

Examples:
1. Cotton and cottonseed.
2. Wheat, which is typically grazed as pasture during part of the year in the central and southern Plains.
3. Wheat or barley in the Northeast, for which straw is a joint product whose value may approach that of the grain harvested.

Representing the output of these enterprises as multiple products with separate prices may enhance comparisons across regions and understanding of the CAR by the intended audience. If the analysis focuses on interregional comparisons of a specific commodity, joint products that are unique to each region are priced and subtracted out to leave comparable per unit prices and net costs.

> **Examples:** Comparing CAR estimates for grains across the country might require that the revenue and cost of straw or grazing be estimated and subtracted from the total activity revenues and costs to give an estimate that represents only the revenues and costs for grain.

Thin Markets

Markets are considered to be thin when there are relatively few transactions per unit of time. Examples include markets for pasture, niche products, new products, and residual markets or markets for distressed supplies of products. Small changes in the quantity supplied can result in large changes in price—prices can be very low if supplies are plentiful or very high if supplies are short relative to demand.

> ***The Task Force recommends that if the commodity traded in a thin market is a secondary commodity, intermediate product, or joint product of the farm or enterprise, a multiyear average price to smooth out large systematic fluctuations in the price be used.***

> ***The Task Force recommends that if the commodity for which a farm-level projected CAR estimate is being prepared is the primary commodity of the farm or enterprise, and it is traded in a thin market, estimates over a range of low to high prices be prepared.***

> **Example:** If dairy farms in an area sell hay in years favorable for hay making and purchase hay in years of short supply, the profitability of the alfalfa and dairy enterprises is made more volatile by the swings in the market price of hay. Because haying conditions affect all farms in a local area, the price of hay is likely to be high when farms need to purchase and low when farms have hay to sell. As discussed in more detail in Chapter 2 in the section entitled Valuing Produced Expendables and the Capital Services of Owned Capital, the hay enterprise should be credited with the net price received from selling hay off of the farm, including the low price when excess hay is actually available for sale. The dairy enterprise should be charged the net cost of having hay of comparable quality delivered to the farm. Thus, both the dairy and the hay enterprises will be influenced by the volatility of hay prices.

Nontraded Commodities and Commodities Utilized on the Farm

Some intermediate products produced on the farm and joint products of an enterprise may be utilized on the farm. Some of these products may not normally be traded. Corn silage and manure are two examples of non-traded products; others include straw and nonstandard feeds in feedlots. The corn grower who feeds hogs is one example of a traded product that is often used on the farm. What is the value of the corn fed to the hogs? There are two options: (1) use the market selling price net of selling costs, or (2) use the cost of purchasing corn and having it delivered to the farm. As mentioned in Chapter 2 and here stated as a recommendation, the preferred approach is the second one.

> ***In the case of factors produced and utilized on the farm, the Task Force recommends using the cost of purchasing the factor from off-farm as the cost of the factor to the utilizing enterprise because this reflects the opportunity cost of the factor to the utilizing enterprise.***

The disadvantage of the second approach is that a farm producing corn that is fed to hogs has a net selling price for corn grown, a margin for marketing the corn to the hog enterprise (or a return to vertical integration), and a (possibly) higher price of corn charged for corn consumed by the hogs. However, this approach sends the appropriate signals concerning profitability of resource use in both enterprises. Furthermore, it requires the most easily collected price data for aggregate CAR estimates. **An alternative and commonly used approach is to use the net selling price of corn for all of the corn produced on the farm that is used by livestock on the farm. This approach credits any profit from vertical integration to the livestock enterprise.** Chapter 4 contains further discussion of purchased and farm-raised inputs.

For nontraded commodities, the production costs of the intermediate product or the private treaty prices and conditions for the joint products constitute the only estimates of the opportunity cost or value of these items. General issues involving joint costs are discussed further in Chapter 9.

Marketing Rights

Marketing rights, often established by federal marketing orders, define the quantity, quality, and timing of the sale of the commodity. This relationship creates several interesting issues within itself. First, for some commodities the mix of joint products is determined by shipping quotas that are related to commodity prices and expected supply and demand for the commodity. Second, the final yields of the specific salable commodities are determined by the price. Third, obtaining access to the marketing order (the right to produce and market) may need to be purchased. The first two issues are discussed here; the cost side is discussed in Chapter 9.

> **Example:** Navel oranges, through the navel orange marketing order, are subject to market prorates, shipping holidays, and control of the flow of product to market. Fresh packed oranges and juicy oranges are marketed in separate areas, with the portion of any farmer's oranges going to fresh pack strictly determined by the market administrator. If fresh quotas are low, then so is fresh yield. The remainder of the production goes into process production increasing the juice and/or industrial use yields.

> **Example:** Some grains produced in the Prairie Provinces of Canada are subject to Canadian Wheat Board grain delivery quotas. Such restrictions may affect the pricing options available for these commodities as well as the timing of delivery and sale.

When access to markets is limited by these restrictions, neither price nor yield is defined by an open, public market. Consequently, great care must be exercised in interpreting price and yield values or in applying them to alternative time periods or geographic locations. In these situations, *both* yield and price information may be nonmarket values. The source of the data in these cases should be explained in notes to the CAR estimate.

Pricing Consumer Oriented Commodities

The point in the production process at which the commodity is priced has been described previously as the point at which the commodity leaves the ownership of the grower. Although selecting the actual point of transfer varies from commodity to commodity, the selection of this point is critical in many systems for determining the actual cost of production. This selection is particularly important for commodities that require little processing prior to consumer purchase. For these commodities every effort should be used to define clearly the intent of the CAR and to identify the cost of the system even if those costs include some postharvest processing and marketing.

> **Example:** Fresh vegetables and fruits are often taken to grower-owned or controlled packing houses where the commodities are cleaned, sorted, graded, and packed for shipment. These costs are clearly a part of providing a product for final sale due to the ownership and control of the packing house, and are a part of the grower costs. Inclusion of processing costs for fresh produce may distort CAR comparisons with other producing areas and/or commodities that list processing costs as a separate marketing enterprise. However, the relevant processing costs should be included when they are required to receive the price listed in the CAR.

As discussed in the section of Chapter 5 entitled Other Commodity-specific Costs, cost items should not be subtracted from the commodity price, if at all possible. For example, transportation or packing costs should not be subtracted from the price of the product, but included as a cost. The reported product price should be the price before any costs are deducted. If it is not possible to have the cost items separated from the commodity price, the CAR estimate must indicate clearly which cost items have been included in the price.

Forward Pricing

Forward pricing includes several forms of cash forward contracting (pricing and/or sale before delivery or before production), futures marketing (hedging or cash-to-futures roll-overs), and hedging with options. When the product price used in calculating revenue assumes one of these pricing methods, the costs involved with these transactions should be included in CAR estimates.[3] For many commodities there will be

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[3]Use of futures or options for purely speculative purposes should be excluded from the revenues in CAR estimates.

a counterpart set of forward contracting alternatives on the buying side (e.g., grain for livestock feed) creating the same estimation problems on the cost side.

When forward pricing is part of farm management practices, selling (or buying) and delivery may be significantly separated in time. In many cases, sale (or purchase) will precede production (or use). As a result, postharvest prices for the contracted product may be very different from the contract prices actually received, and revenue will differ from arbitrarily specified sale dates. Also, if the product is pre-sold there may be no storage or "marketing" costs associated with the contract price. A note of caution is warranted: contracts often have specific delivery requirements that, if not met by the grower, result in significant price reductions. In many cases, two separate CAR estimates may be necessary to illustrate and contrast the sale of contract and noncontract production.

Cash Forward Contracting

Cash forward contracting permits the buyer and the seller of the crop, livestock, or livestock product to agree on several terms of the transaction in advance of the time the product changes ownership. Such contracts usually specify a fixed price subject to premiums/discounts for quality and time of delivery differentials. For example, cash forward contracts offered by elevators to midwestern U.S. grain producers commonly specify the quantity, quality, timing of delivery, grading procedures, terms for dispute settlement, and the price.

The transaction costs paid by farmers on cash forward contracts are typically very low unless the farmer fails to deliver the agreed-upon quantity within an acceptable time period. The contract price received for the quality delivered can be recorded in the revenue section. Any deductions for late delivery and other failure to comply with contract provisions either can be recorded as negative revenue or can be included as marketing costs in the operating inputs section. This entry should be explained with a footnote to the CAR estimates. When only part of the product was priced using the contract and the remainder was sold for the spot price, the quantity sold by each method should be listed as separate entries and the price received for each should be shown. This will enable users to combine the yield and price data in ways appropriate for different uses. If other costs were incurred to fulfill contract provisions, they should be included in the operating input section. For example, if yields are lower than the amount contracted for sale, the producer may need to purchase commodity from other producers to fulfill the contract. In this case, the revenue section should only include the amount produced and sold at the contract price. The difference between the buying and selling price of the additional commodity purchased should be included as a cost.

It seems unlikely that those preparing projected CAR estimates would want to make the calculation assuming use of a cash forward contract. In the event they do, the following entries should be included. The price offered by the buyer can usually be obtained either from direct quotes of buyers or by applying historical differentials between the futures price and the contract price for the same location and season of the year. In addition, it is necessary (1) to determine the proportion of the expected production that is priced with the contract, (2) to estimate the expected cost of fulfilling the contract when production is less than the amount contracted, and (3) to estimate the expected revenue from producing and selling more than the amount contracted. Thus, the receipt section of a projected CAR assuming the product is being priced under a cash forward contract should include (1) the contract price times the amount contracted, and (2) the expected receipts of selling excess production on the alternative market. The operating expenses should include the expected costs of fulfilling the contract when the actual production is less than the contracted amount. The assumption used in entries should be explained in notes to the CAR estimates.

Futures Contracts

Farmers who use futures contracts to hedge commodity prices incur some additional transaction costs. It is important in collecting prices received for use in historical CAR estimates to obtain the price received for the commodity in the cash market and the costs associated with the futures contract. These costs would include the commission fees paid and interest on the money used to meet margin requirements. To fairly reflect the net price received, it is also important to obtain information on the gain or loss on the futures transaction. A historic CAR estimate for a commodity hedged would include the following entries in the revenue and operating cost section: (1) revenue received from cash sale (quantity times the spot price received); (2) gain (loss) on the futures contract; (3) commission fees on the futures contract; and (4) interest on the capital required for margin calls. It would be appropriate to include the first two categories in the revenue section of the CAR and the final two in the operating cost section. Notes explaining the entries should accompany the historical CAR estimate.

It seems unlikely that preparers of projected CAR estimates will want to assume hedging because of the complexity of making the calculations. Preparation of a projected CAR estimate requires calculating the expected value of each of the four categories of receipts and operating expenses discussed in the previous paragraph. Making these estimates is sufficiently complex that preparers are unlikely to include the efforts of hedging in the projected CAR. When they do, knowledge of the local basis, the commodity, commission fees, and margin requirements is important in preparing such estimates. Generous use of notes to explain the assumptions should accompany the projected CAR estimates. Readers interested in pursuing this topic are referred to a textbook on commodity marketing (Purcell; Marshall) for a discussion of procedures to use in making the calculations.

Futures Options

Options are similar to insurance programs. A premium is paid irrespective of whether the option is exercised or allowed to lapse. If exercised, an option position is converted to a futures position which presumably will lock in a price for the farmer.

Historical CAR estimates with pricing through futures options include the revenue and cost entries noted under futures contracts above. In addition, the estimate would include another line of operating costs to list the cost of the option contract. Similarly, projected CAR estimates with pricing through futures options include the four categories of revenues and operating costs listed in the previous subsection, plus another line of operating cost to list the cost of the option contract. To the extent that the purchase of this options contract affects revenues, it is essential that these also be included in the same CAR estimate. In analyzing options and futures, it is essential to keep hedging and speculative activities separate, and to monitor proxy hedges and roll-overs.

For farm management purposes, basic market related information such as price forecasts, seasonality, and forward contracting opportunities are required. Estimators working in conjunction with market analysts may be able to provide some of this information when significant opportunities on specific commodities exist.

Selecting the Appropriate Prices: Transactions or Averages

The selection of prices for the calculation of revenues is determined, as are most other CAR variables, by the use for which the CAR is estimated. In some cases it may become critical to examine the records of individual transactions at either the farm level or some marketing association level to determine the specific prices or revenues needed to examine the issues at hand. Aggregation of prices at higher levels is often inappropriate in project planning and specific planning for farm investment because these aggregates do not reflect the condition for which the activity is being planned. For many types of aggregate analysis, however, the use of state or national prices may be the appropriate procedure.

Sources of Price Data

Data sources for prices include sources that are of primary importance for historical analysis as well as those for planning and decision making as shown in the following list:

> **Historic Data:** farm-level data; state/federal data; marketing associations, cooperatives, and private dealers.
>
> **Forecast Data:** contracting agents; futures markets; researchers, forecasters, and forecast models.

In contrast to output data, price data are based primarily on secondary data collected, processed, and provided by government agencies. Sometimes private sources are the only source of specific data needs. These data reflect an accounting of what has happened in the past.

Historic and Forecast Data

Historic data are of considerable importance in analyzing the performance of a region or farm relative to the existing markets for the commodities that are produced. The difference between historic and forecasted prices is critical, and the choice between the two concepts is established by the purpose of the CAR estimate. Forward planning requires some anticipation of commodity prices and relationships among prices. Of considerable importance is the term of the forecast and how it relates to the goal of the CAR. Short-term farm planning requires considerable accuracy of forecasting while longer-term planning for public policy decisions may require more general and less specific information on long-term trends for general commodity prices. Several important sources of this type of data are described briefly in the following sections.

Farm-Level Data

Actual prices received by a farmer can often be determined by examining the farm's records. One can start with actual prices received and proceed by making appropriate adjustments for hauling costs, promotion costs, dockage, co-op fees, and other charges that were deducted to obtain gross sale prices.

State/Federal Data

Historic data are available from ERS and NASS for the major and many of the minor commodities. Periodic publications provide summary data for prices at the state level and occasionally for more local markets. The data are usually reported as average price received by farmers. This type of measure aggregates information across transactions for all qualities of the commodity and across the entire geographic area being considered. Appropriate adjustments may need to be made to reflect regional differences.

Another important source of historic data is the USDA's Agricultural Marketing Service publications. These publications are often developed in conjunction with state agencies concerned with the regulation of the quality of the shipments of specific commodities.

Some states and/or counties collect and publish data in addition to that routinely collected by NASS or state level departments of agriculture. In California, for instance, the County Commissioner publishes data on sales of commodities within the county. The Iowa Department of Agriculture sometimes collects data via special surveys to supplement regularly collected data.

Marketing Associations, Cooperatives, and Private Dealers

Like farm data, the price data from marketing associations and cooperatives, if these data can be tapped, offer a measure of actual performance of a farm or a group of farmers. The data are on record at the market association or cooperative specifically because the association or cooperative is the marketing agent for a set of growers. Private dealers and even specialized media sources may be the only source of recorded specialized data. For example, regional or quality-specific data required may only be available from dealers or specialized farm newspapers.

Contracting Agents

For farm planning purposes, prices provided by potential purchasers of a contracted commodity are important in many cases. Many farmers are able to establish through contracts for delivery of commodities the price that will be received at delivery. Forward planning is greatly enhanced when the price of the output can be predetermined. As noted earlier, contracts often have specific delivery requirements that, if not met by the grower, result in significant price reductions. Thus, price data should be obtained on the price received for the proportion of the output that meets the delivery requirements and the proportion that does not meet the desired delivery schedule.

Futures Markets

Futures markets represent one way to anticipate or forecast the prices of commodities. Although this method is often used as the expected price at a future point in time, it has many potential pitfalls that limit its effectiveness as a forward planning tool. Futures prices are simply a single day's anticipation of the future and, of course, change daily as conditions change. Furthermore, the basis (futures price minus the local cash price) varies seasonally and by the market conditions that exist. Thus, futures prices should be used cautiously as a method of calculating projected prices.

Researchers, Forecasters, and Forecast Models

State university, federal, and private researchers have established complex forecasting models for agricultural commodity prices (usually the "bulk" commodities). These forecasts are extremely important in establishing estimated future revenues to be used in CARs for individual producers as well as policy and public investment decisions.

Recommendations for Pricing Output

Cost and return estimates are typically prepared for the production process, but the point at which production ends and marketing begins is not always obvious.

> ***The Task Force recommends that commodities in CAR estimates be priced at the point in the production process at which the commodity leaves ownership of the grower. In cases where the timing of transfer is after the end of the calendar year, the estimate of the price at the end of December should generally be used. For perennial crops, a time point consistent with normal harvesting patterns should be chosen.***

Commodity prices used in CAR estimates should reflect market value. Pricing a commodity with an established market, such as hard red winter wheat, presents fewer problems than pricing commodities that are traded in thin or nonexistent markets. The following general hierarchy should be used in pricing commodities:

1. Use market price when available;
2. Use an annual price that is seasonally adjusted based on historical data, surveys not conducted every year, estimates for similar markets, etc. for continuously marketed commodities;
3. Use a proxy in nonexistent or thinly traded markets; and
4. Use cost of production as an alternative when no other market or proxy is available.

The first situation is evident and will not be discussed further. The second situation may be appropriate when monthly prices are not easily obtainable but a seasonal index based on previous years is available. For a projected budget, an econometric estimate of the season average price may be available but monthly prices may not. In this case a seasonal index may be a useful way to forecast monthly prices. The third situation occurs for a crop like corn silage. Corn silage could be priced on a feed-equivalent basis as a proxy. For example, corn silage could be valued at 25% of feeder quality hay, or it could be valued based on its corn grain content.

GOVERNMENT PROGRAM RECEIPTS

Government commodity programs have often provided a significant proportion of the income on many farms, especially in the United States, Canada, and Europe. Government farm programs frequently supplement (subsidize) farm revenues for farmers who have historically produced a given set of commodities. In the United States, commodities that have been included in such programs include upland and extra-long staple cotton, wool and mohair, corn, oats, grain sorghum, wheat, sugar, barley, peanuts, rye, rice, and tobacco. The subsidy process has varied by commodity and has changed from year to year to meet the immediate problems of producers and market supply and demand. Subsidies usually come with a strict set of guidelines as legislated by the governments involved. Producers are often required to reduce production, follow specific production or marketing practices, purchase insurance, or participate in educational programs in order to receive subsidies on all or a portion of their production. Even during periods when government intervention is declining and the move is towards a freer market, some programs affecting producer revenues usually exist. For example, export promotion programs may lead to a higher price for specific grades of a given commodity during a particular year.

Crop Programs

For appropriate crops, and when a CAR estimate assumes farm program participation, costs and returns for such participation should be included. Farmer programs that retire land from production, but are not crop/commodity specific such as the Conservation Reserve Program (CRP), usually warrant a separate CAR estimate.

Determining the actual or potential revenues from government programs requires that farm conditions be stated explicitly. These conditions vary depending on the purpose of the CAR estimate. Historic farm level parameters can be obtained from farm records which establish historic payment acreage and payment yields. Farm receipts may be constrained by legal limitations such as the upper limit of $50,000 per "farmer" often imposed for U.S. farm programs. For payment purposes, the business organization of the farm further determines the upper limit on payments. In reality, exact farm program payments can only be estimated after the season has ended. Government program payments can be taken fully into account only within a whole farm definition that includes farm size, farm business organization, and crop mix. However, several farm-specific conditions can provide an important base if government programs are to be estimated as a part of a CAR. For the set of farm programs that existed in the 1980s and early 1990s these conditions would include

1. total farm acreage of crops covered by a particular program (Crop Base);
2. acreage that must be set-aside or otherwise differentiated as a percentage for each crop (Acreage Reduction Program (ARP));

3. payment yield for each crop if this is different from actual yield;
4. number of business partners and payment limitations;
5. payment acreages, flexible acreage, and participation options; and
6. payment rates (deficiency rate).

Historic estimates for the 1950s and *60s would need to consider alternative payment schemes such as the soil bank, government storage programs, etc. With the gradual elimination of many traditional U.S. farm programs starting in the mid 1990s, cost estimates must consider those revenues that are applicable to a given year and program eligibility status. Long run estimates for 10 to 15 years into the future need to specify a set of programs consistent with the policy scenario adopted for the analysis. A major consideration is the basis upon which the estimate is to be made.

> ***The Task Force recommends that all estimates be made on the basis of planted acres of any individual crop. If the crop being considered is a farm program participation crop requiring the idling of certain acres, the costs of production should include a cost of maintenance of set-aside land as a pro-rata share of the total required farm set-aside or diversion including appropriate allocated costs.***

Deficiency Payments

The options for farm program participation in the major government-supported crops are numerous and vary somewhat by commodity. It is important that a consistent approach be used in making CAR estimates and that estimates be made on a planted acre basis with the costs of ARP maintenance included in the cost. In some programs "flexibility acres" are usually assumed to be planted in some commodity with cost allocation attributed to that crop. Other options such as 0/50/85/92 participation provide complexities of allocating the cost of maintaining land required for compliance that is not used to produce the commodity.

> **Example:** The California cotton farmer in the cotton/almond example received a deficiency payment of $196.35/acre on 417 acres as determined by the 556 acre cotton base reduced by the 10% ARP (56 acres) and the 15% Normal Flex Acreage (83 acres). At an assumed payment yield of 1,100 lbs/acre, the deficiency payment was $0.1785/lb for total government program receipts of about $81,878, which exceeds the $50,000 payment limitation. If the farm is a partnership, perhaps between two family members both of whom are counted as individual farmers, the payment limitation is $100,000 for the farm and the deficiency payment is $196.35 per planted acre. However, if the farm is a sole proprietorship and the payment limitation is $50,000, the deficiency payment would be 81.88% of $196.35, or $160.77 per planted acre.

Consistency in determining the allocation of costs and revenues is most important. An example of a case that is difficult to determine is the case of skip-row cotton which is based on farming most of a farm's acreage as cotton. Market revenues are determined by the yield on the entire acreage, but government payments are based on farm program base acres and yield. Historic yields are determined from program base acres, leading to a distortion in the actual yields.

> **Example:** A farmer with an 80-acre cotton base on a 160-acre farm will plant cotton in a skip-row pattern on all 160 acres. Yields and government payments are based on 80 base acres even though all 160 acres are planted in cotton. In this case, each planted acre requires two acres of land. The yield is 500 lbs./planted acre. The costs for each planted acre include tillage and other costs for 2 acres of total land.

> **Example:** Grain–summer fallow rotations create similar questions about determining planted area. If a farmer has 160 acres, 80 in wheat and 80 in summer fallow, the wheat yield is only calculated on 80 acres. However, the summer fallow is the common practice and the grain could not be produced without the fallow acreage. In this example, each planted acre requires two acres of land. The yield is calculated per planted acre and the costs include the costs of the acre actually planted to wheat plus the cost of one acre of summer fallow.

Marketing Loan Deficiency

Some farm commodity programs provide for additional grower incentives to move commodities from government storage into the market by adding a payment called the marketing loan deficiency (MLD) payment. This payment provides an additional revenue to growers equal to the difference between the Commodity Credit Corporation (CCC) loan rate and an "adjusted world price" (AWP), if the AWP is below the loan rate. For Upland cotton, the AWP is computed weekly and becomes information to be used as a part of the farmer's marketing strategy. Commodities receiving a marketing loan deficiency payment cannot be placed in CCC loan stocks. Marketing loan payments are subject to $75,000 payment limitation per farm and are computed separately from deficiency payments.

> **Example:** In the California cotton farm example, the farmer received an MLD payment (popularly called POP or Producer Option Payment) amounting to $74.80 for each acre of the 417 acres planted to cotton. The total payment for all of the production amounted to about $31,191, which is below the $75,000 limitation on MLD payments per farmer.

Since the MLD is available only when the AWP falls below the loan rate and only when the farmer chooses not to exercise the right to place the crop under the CCC loan program, the actual receipts depend on the farmer’s decision. The actual amount ineligible for the MLD is the same amount ineligible for the CCC loan. The 1996 legislation only authorizes MLD payments for Upland cotton production.

Historic estimates of revenue should reflect an estimate of the farmer’s actual receipts including those from MLD payments. For forecasting revenues, MLD cannot be anticipated and should not be included except in the form of a substitute price that includes potential farmer receipts up to the established Target Price plus local quality adjustments as appropriate.

Production Flexibility Contract Payments

The Federal Agriculture Improvement and Reform Act of 1996 offered producers a onetime Production Flexibility Contract (PFC) to cover seven years, 1996-2002. The program complicates preparing

CAR estimates because the payments are associated with the historical base acres on each farm, not the number of acres and types of crops currently grown. The payments do not affect decisions concerning the mix of crops currently being grown and should probably not be included in CAR estimates used to make future farm organization plans. On the other hand, historical CAR estimates should, in some way, include the payments to reflect farm income levels accurately. The difficulty is determining how to divide the annual payment between crops and among acres of each crop. To reflect the allocation of payment income to each CAR estimate accurately, it is necessary to know the size of farm and the number of base acres for that farm. Conceptually, the PFC payment is a source of farm income that is very much like an overhead expense; it is difficult to allocate, but does affect farm profitability. How CAR estimate developers include PFC payments depends on the purpose of the estimate. A useful guide is to include them in the estimates in the same fashion and at the same point as overhead costs are included. A discussion of this overhead is contained in Chapter 9.

Livestock Programs

Several livestock commodities have had direct government payments to qualified producers, but they are being phased out. Congress eliminated the honey support program beginning in fiscal 1994. The incentive payments for wool and mohair, based on the qualified production and the incentive rate, were phased out over 1994 and 1995. The income from these payments should be included in the enterprise receipts only through 1995.

Dairy program provisions support farm income indirectly through government purchases of processed milk products in support of the price. Therefore, prices established in the local market reflect the effects of government purchases, and no further computation of additions to producer receipts is necessary. See the discussion of marketing orders that follows for an explanation of the cost considerations.

Marketing Orders

Marketing orders do not, in general, establish market prices; rather, they establish shipping quotas, quality standards, or production limits. This process clearly restricts the entry of some products into the market and influences both the price and quantity of marketable goods. There is no direct government payment for marketing orders that most commonly govern selected fruit and vegetable crops by region. Dairy production is governed by marketing orders in some areas of the United States. Thus, there are no direct revenues to be included in CAR estimates although there may be some costs due to marketing and association dues that should be included in the CAR estimate for a commodity sold under a marketing order.

Disaster Payments

Government disaster assistance payments should be included in historic CAR estimates when these payments have been received and can be allocated to specific commodities. The expected use of the CAR estimate determines the need for including these payments in the revenue estimates. However, disaster payments cannot be anticipated and should not be used in projected CAR estimates. Given this difference in recording these payments, disaster payments used to replace or repair land and capital improvements should be included in historic CAR estimates, but they should not be included in projected CAR estimates.

In summary, the Task Force recommends that government program payments be included in the revenues of CAR estimates if (1) the costs of obtaining program benefits are included in the cost calculations, and (2) the benefits are not otherwise reflected in the computed price and yield for the outputs.

MISCELLANEOUS REVENUES

The discussion covers four potential sources of miscellaneous revenues: (1) insurance revenues for loss of crops and livestock, (2) assessment rebates, (3) consumption by the farm household, and (4) cooperative dividends. Although other miscellaneous revenues may be available to a farm, they are generally minor and will not be considered here. When other revenues occur and can be connected to a commodity, the revenue and any associated costs should be included in the CAR estimates.

Insurance Revenues

For purposes of this report, insurance revenues are defined as the following two types.

Commodity Loss or Damage Insurance: Crop/livestock insurance that is associated with expected outputs, e.g., replacing commodity revenue if a claim is made. Revenue is uncertain, depending on the production environment, but the farmer may have significant (or frequent) probability of collecting.

Commodity Stabilization Insurance (where it exists; Canada has several examples as does Iowa): The premium is related to commodity value or revenue protection; payouts are in relation to market conditions or production problems and have a significant probability of occurring. Claims are made against less-than-target revenue.

Cost and return estimates should include insurance costs where they can be identified and designated as commodity specific. In such cases, expected revenues should be included in the total revenue estimate. Insurance premiums on inputs (e.g., insurance on feed, fertilizer, and seed stored before use) will usually be included as an overhead cost. Because any revenues will likely be limited to replacement cost, revenues from insurance on inputs should be omitted from revenues.

Commodity Loss or Damage Insurance

The use of publicly subsidized or private commodity loss insurance varies by region within the United States and Canada. In many areas crop insurance has become mandatory if a farm wishes to receive bank financing for the production activity. In other areas, the expected gains far exceed the cost and as a result farmers use crop insurance as a common practice. Where common practice is to utilize commodity loss insurance, the cost of the insurance premium should be included in the CAR estimate. The choice of participation level (e.g., 50% or 65% coverage) is arbitrary but should also reflect the cost used in the estimate.

Insurance revenues should not be included in developing projected CAR estimates because the intent of the revenue is to maintain farm income at levels normally anticipated. Forward planning usually considers normal prices and yields and, thus, automatically adjusts revenues to the levels expected.

Historic CAR estimates based on specific years of production data should include an estimate of revenues received from commodity loss insurance if the use is for performance analysis at the farm level and the actual (lower) yields and/or prices are used. For regional CAR estimates, a weighted average (using the insurance participation rate) revenue from commodity insurance should be used.

Commodity Stabilization Insurance

This form of insurance insures against loss of targeted income and should be treated in a manner similar to commodity loss or damage insurance. For planning purposes the inclusion of costs and potential or expected revenues should be included if the decision maker commonly uses the insurance. For regional estimations the historic returns should be weighted by the participation rate.

> ***In summary, the Task Force recommends that historical CAR estimates include revenues from insurance claims against any included costs. Expected insurance revenues can be derived from historic payment records of insurance companies and federal agencies and from insurance participation rates. However, claims often seriously lag premium payments.***

If stabilization insurance costs and revenues are significant numbers (as they have been sometimes in Canadian grains and livestock programs), "with" and "without" estimates could be prepared to provide relevant information on the benefits and likelihood of voluntary participation.

Assessment Rebates

This revenue source is derived from assessments based on commodity output imposed on growers through state taxing authority. The assessments are usually established on a per unit output basis and extracted from the growers' revenue checks at the first point of sale to be used for specific purposes such as market development, research and promotion, and insect control and eradication. Assessments are, in some cases, "voluntary" and may be returned to the producer in whole, or in part, under certain conditions. Assessments should be charged as cost against the anticipated revenue of the activity.

> ***The Task Force recommends that involuntary assessments be charged as input costs to growers. Return of assessments (usually by way of a special application process)***

should be considered as a possible revenue source depending on the extent of applications for rebates. These revenues are usually small.

For regional historic CAR estimates, actual data on rebate rates can be obtained and used as a weighted average increase in revenues.

Example: Growers in a specific area are charged $2.00 per bale (480 lbs) of cotton for insect control. However, 40% of growers request a refund of this assessment. A cost of $2.00 per bale could be included in the input costs section and a revenue of $.80 per bale (40% x $2.00) could be included as revenue in the regional CAR estimate. Alternatively, the $.80 could be deducted from the gross assessment, resulting in a net assessment of $1.20 per bale in the operating cost section.

Consumption by Farm Household

The value of enterprise production that is consumed by the farm household and hired workers without compensating the business in cash should be included in enterprise revenue. For example, when the farm household and hired workers consume milk produced by the dairy herd, the quantity consumed should be included as a source of income in the revenue section of the dairy enterprise. The milk should be valued at its net selling price. The value of these products represents production by the enterprise and should be added to cash operating income to account more accurately for the income produced. The expenses used to produce these products are normally included in the appropriate expense categories of the enterprise. This consumption represents a small adjustment to the CAR estimates for larger farms, but it may represent a large proportion of income on smaller and subsistence farms.

Cooperative Dividends

Many growers participate in cooperative or other similar enterprises that rebate through dividends a portion of the costs of inputs. Although this type of income is usually small relative to the total value of other revenues, it reflects a potential cost savings or revenue addition that should be measured. Efforts should be made to clarify and identify marketing and input dividends that affect grower production and marketing costs.

Example: A milk marketing cooperative annually provides a dividend $.10/cwt to be paid on the quantity of milk marketed by participating members. A dairy farmer sells 250,000 cwt of milk through the cooperative and receives a dividend check for $25,000 to be credited to the revenue received for milk production. The dividend may, in fact, lag actual production by several years. Care should be taken to include the price paid by the cooperative and also to include the present value of patronage dividends related to the dairy enterprise.

SUMMARY

Revenue calculations for CAR estimates should be consistent with the conditions specified for the estimate and with the use of the estimate. Expected or historic yields and prices are the primary components of computing expected or "actual" revenues. Appropriate recognition of variability of revenues should be included in both planning and historic estimates. If costs for participation in government programs, purchase of crop insurance, membership in marketing organizations, and so forth are included in estimating total production costs, then revenues consistent with these expenditures should also be included. In particular, prices and yields and other payments should be in accord with these production costs.

Separation of production from marketing is not always easy or appropriate. The gains from sound marketing strategies are as much a part of modern farming as the gains from good production management. It is important to include both the costs and returns of such activities.

CHAPTER 4

PURCHASED AND FARM-RAISED EXPENDABLE INPUTS

Operating costs arise from the use of expendable inputs during the production process. An operating or expendable input is completely used within the current production period. This chapter discusses procedures to use in estimating the cost of most expendable or operating inputs. Those inputs not covered here are the operating portion of machinery and labor costs, and charges for custom services which are discussed in Chapter 5. The interest expense associated with the acquisition of operating inputs is discussed in Chapter 2, and also in Chapter 5.

Capital inputs, as opposed to expendable inputs, are factors of production that are not used up during a single production period, provide services over time, and retain a unique identity. The term **durable asset** (input) is often used to describe **physical capital** because the word durable denotes long-lived or not temporary. These inputs are discussed in later chapters of this report. Most inputs are easily classified as expendable or capital. Some classification problems arise, however, when considering an input that has short-term carryover effects, such as phosphate fertilizers that supply nutrients over more than one year. These issues are discussed for the relevant input categories throughout this and succeeding chapters.

An operating input may be purchased from off-farm suppliers or may be a primary product or a by-product that is produced by another enterprise on the farm. In either case, the input's cost per unit of production must be estimated. Two alternative methods of estimating the cost of an operating input are commonly used.

1. The first method is straightforward: Multiply the price of the input (if it was purchased from an off-farm supplier) or the opportunity cost of the input (if it was produced on the farm) by the quantity used per unit of production (i.e., the application rate) to obtain the cost per unit of production. Thus, the input's price (or its opportunity cost) and quantity used per unit of production must be known or be estimated. The value of the input must be measured in the same units as the application rate (e.g., $12.50/gal times 0.5 gal/acre equals $6.25/acre). Methods to calculate the opportunity cost of inputs that are produced on the farm are discussed by type of input throughout this chapter.

2. If it is not possible to obtain the actual values, or estimates of the input's price and quantity, it may be necessary to derive an estimate of the cost per unit of production from farm accounting records or income tax records. This situation commonly occurs with miscellaneous supplies, with general office expenses, or with a fertilizer expenditure for the farm that is not broken down by crop. In cases where the production period does not coincide with the record-keeping period, care must be taken to assure that all expenses related to the production period are utilized. If the total cost for an input is available on a whole-farm basis, the cost must be allocated to the various enterprises produced on the farm. An appropriate allocation procedure should be used and

documented; these procedures are discussed in Chapter 9. Care should be taken to assure that the shares sum to one (or 100%). Once the total cost has been allocated to individual enterprises, the cost per unit of production is determined by dividing the total enterprise cost by the appropriate unit of production (e.g., $12,000 divided by 600 acres equals $20/acre).

The choice of reporting format is dependent in part on the method selected to estimate the cost of expendable inputs. The alternatives range from reporting a detailed list of each input, with its trade name or formulation, price, quantity, and cost, to reporting a general name for a group of similar inputs with their aggregated cost. A detailed listing of inputs provides a great deal of insight into the production process. The use of specific input names allows a precise description of each input which in turn provides a reference point for projected or historical cost estimates. A major advantage of detailed listings is that the causes of cost changes between time periods or between production areas can be identified quickly and easily. This method also has major advantages to new producers and to those who wish to compare production alternatives. A disadvantage is the appearance of recommended inputs by name when there are other inputs and methods available. Furthermore, historical cost and return (CAR) estimates aggregated over a sample of producers require use of generic categories, e.g., herbicides, insecticides, etc., rather than individual products.

With the second reporting format, similar inputs could be grouped and given a general name (e.g., herbicides, insecticides, seed, fertilizers, and feed). After estimating the cost of each input in the group, the total cost of the group would be derived. Listing the total cost of each group will provide the user with the desired cost estimate, reduce the amount of information presented, and avoid the appearance of product recommendation. The first alternative for estimating costs could be used, but this information would be retained in supporting documentation. This approach can be used to prepare CAR estimates for individual farms as well as to summarize costs over a sample of farms using somewhat different brands of inputs.

INPUTS USED TO PRODUCE CROPS

Fertilizers

Fertilizers include natural and synthetic materials that are spread on or worked into the soil to increase its fertility. Nitrogen, phosphorus, and potassium compounds are common types of fertilizers, as are numerous micronutrients including sulfur, magnesium, and zinc. The units, quantities, and prices of N, P_2O_5, K_2O and other nutrients should be reported. Often, mixtures or formulations such as 5-15-30 (5 pounds of N, 15 pounds of P_2O_5, and 30 pounds of K_2O per 100 pounds of fertilizer) are used. In this case the quantity applied and the price of its mixture can be reported. Manure is also used to fertilize the soil and improve soil tilth. Lime, a soil amendment which is used to ameliorate soil acidity, may also be classified as a fertilizer.

Most fertilizers are purchased from off-farm suppliers at a known market price and are applied at a known rate per acre. Thus, the cost is simply price multiplied by quantity applied. For example, if 122 pounds of NH_3 are used per acre, at a price of 16 cents per pound, the ammonia cost is $19.52 per acre. Fertilizers, especially dry bulk starter fertilizers and custom blends, are often applied with specialized application equipment by the fertilizer dealer. When possible, the cost of the fertilizer material should be separated from the application cost. This split may be difficult to make when custom blend prices are quoted on an as-applied basis. However, a cost estimate based on the fertilizer application rate and the cost of individual nutrients could be used to separate application cost from fertilizer cost.

Carry-over effects can pose a particularly difficult allocation problem. In many instances, lime is applied to control soil pH, or gypsum is applied to control salinity with the expectation that its useful life will extend five years or more before reapplication is necessary. Since the services of these inputs clearly last more than one production period, the application should be treated as a capital asset whose services are extracted over time. The appropriate way to allocate these costs is discussed in Chapters 2 and 6. In other instances, annual applications of P, K, and other nutrients may be suggested by plant nutrient withdrawal estimates, but because of relative immobility in the soil, these nutrients are applied only every other year or even less frequently. If the excessive application to the first crop is needed to ensure nonlimiting nutrient availability to that crop, the entire cost, whether used by the actual yield, should be allocated to that crop. If the excessive application is chosen to avoid a second annual application, the cost of the fertilizer should be allocated as a capital service over the two periods.

By-products produced and consumed (disposed of) on the farm should also be priced to establish complete CAR estimates for individual enterprises. Manure, for example, may be a by-product of on-farm livestock or poultry operations and used to provide fertility needs of crop production. If a market exists for the by-product, the opportunity cost methods described in Chapter 3 can be used to assign a price to the by-product. When a market is not available, an opportunity cost can be imputed by calculating the cost of other inputs saved by using the by-product (for example, the cost of commercial fertilizer saved by using manure).

Example 1. A by-product with a positive market value consumed on the farm.

One thousand gallons of swine manure contain usable nutrients that would cost $9 if purchased in the form of commercial fertilizer. The application cost of this commercial fertilizer replaced by the swine manure is $1. The farmer applies the manure from the hog enterprise to the corn crop. Transportation and application costs are $7 per 1,000 gallons. The net value of the manure to the swine enterprise is the nutrient equivalent value, less the transportation and application costs, plus the money saved in commercial application cost ($9 - 7 + 1), $3 per 1,000 gallons. The swine CAR estimate would include $9 income for manure, $1 less expense for applying commercial fertilizer, and costs of $7 for hauling and spreading. The opportunity cost of the manure to the corn enterprise is the lowest cost alternative source of fertilizer applied to the field. In this example, the alternative is commercial fertilizer that would cost $9 with an application cost of $1. The opportunity cost or "buying price" of the manure for the corn enterprise is $10 per 1,000 gallons. ***The Task Force recommends that the manure should be valued at its market price or its nutrient equivalent value if a market price is not available. The nutrient content of the manure must be evaluated carefully for losses so the nutrient equivalent value is not***

overestimated. The costs associated with delivering and spreading the manure to achieve the price should be included in the livestock CAR estimate.

Suppose the swine farmer does not have land to which he/she can apply manure. The opportunity cost of the manure to the swine enterprise is the net selling price (local market value less transactions costs born by the seller). Suppose the neighbor agrees to pay $9 per 1,000 gallons applied to his field. The swine producer estimates it will cost $7 per 1,000 gallons to transport and apply the manure. The net selling price would be $2 per 1,000 gallons. The CAR estimate for this swine enterprise would include the $9 in the revenue section per 1,000 gallons and $7 in the cost section per 1,000 gallons.

Example 2. A by-product (which must be disposed) with a negative market value.

A cattle feedlot produces manure that must be disposed due to sanitary, health, space, and environmental considerations. The feedlot owns a small area of crop and pasture land nearby that can accept a fraction of the manure being produced. The amount of manure applied is limited by environmental considerations and the amount of nutrients that can be used by the crop. The remainder of the manure must be shipped some distance and sold to forage producers. The cost of transporting the manure to the distant market exceeds the price received for the manure by $2.50 per ton.

If the amount of manure applied to the owned land is extremely small, it can probably be lumped with the other manure in determining the cost (revenue) of disposal. If not, the estimates should include separate cost and revenue lines for on-farm and off-farm disposal. For the off-farm manure, the opportunity cost to the cattle feeding enterprise is the highest price for which the manure can be sold less any transactions costs. The low value of the waste minus its transportation cost results in a negative net selling price (-$2.50 per ton). The CAR estimate for cattle would include a revenue line showing the revenue received and one or more lines listing the cost of transporting and spreading the manure on the buyer's field. The on-farm manure would be handled as in Example 1.

Seed and Transplants

Seed and transplants for annual crops, perennial but nonpermanent crops, (e.g., alfalfa, asparagus, etc.), and multiyear, long-lived tree and vine crops include the basic components necessary to establish or begin the growth of the producing crop, whether in hibernative seed form, in live growing transplantable form, or in dormant or rootstock transplantable form. Seed and transplant quality and quantity are critical elements in the agronomic or horticultural success of the crop. Although the cost of seed seldom represents a major portion of the total cost of producing row crops, the cost of transplants often represents a major expense in vegetable production. Interperiod allocations of tree and vine rootstock costs are discussed in Chapter 10.

A detailed listing of seed and transplants can be used to provide a great deal of insight into the production/costs process. Variety names and numbers should be used in a very detailed list to provide a specific pricing reference point for current or historical cost estimates and for updating prices. In addition, the costs of seed treatments and coatings should be included if they are incurred. A very specific listing of seed and transplant amounts and prices has major advantages to new producers of the crop and to those who wish to compare crop production alternatives. Price and use data can be gathered from local seed dealers, local greenhouses and nurseries, farmers, or seed catalogs with a minimum of confusion. Amounts can be updated quickly, efficiently, and accurately.

Another major advantage of detailed seed and transplant amounts and prices is that the causes of cost changes between time periods or between production areas can be quickly and easily identified; a change in cost can be attributed to quantity change, price change, or variety change. A major disadvantage of detailed listings is that a typical or average amount and variety must be identified. It may be particularly difficult to provide a detailed listing for the aggregate CAR estimates, where the average quantity, price, and dollar value can be listed. In situations when the quantity and price vary widely, common practice is to list only the lump sum dollar value.

Various compromises between a detailed listing and reporting a total expenditure for all seed can be used. These compromises attempt to pick up the specific advantages of a detailed listing while attempting to avoid large-scale surveys of seed suppliers to collect data that will likely not have a large effect on relative profitability between crops or between production regions. Compromise alternatives might include a supplementary schedule of detailed varieties, use amounts, and prices to keep the report as uncluttered as possible.

Use of field run or farm-produced (nonpurchased) seed and transplants is common for some open-pollinated small grains, for preseason greenhouse production of transplants for some horticultural crops, and for on-farm nursery production of tree and vine rootstock supplies. For nonhybrid, or open-pollinated, seeds retained from the production of a previous crop, a seed value will need to be assigned using the procedures to estimate the value of farm-raised inputs discussed in the section of Chapter 2: Valuing Factors for which there is no Market Transaction. For the production of transplants or rootstock, two major alternatives exist: producing plants for later replanting could be treated as a separate enterprise, or this enterprise could be included as an integral part of the whole production process. The first, or separation approach, is most useful in situations in which transplants are produced for sale as well as for on-farm replanting, or in which additional transplants must be purchased. In each of these separation situations, the net market selling price is readily available and should be used to value the seed or transplants to the enterprise producing the transplants. The enterprise planting the seed or transplants should value them at the net market buying price. The difference between the two is a return to marketing or vertical integration. Further discussion is contained in Chapter 3 and Chapter 10.

Pesticides, Growth Regulators, and Harvest Aids

Pesticides are applied to soils, seeds, or plants to control or destroy pests such as weeds, insects, and diseases. Growth regulators are used to promote or inhibit plant growth at certain stages of development. Harvest aids, such as defoliants, are used to better prepare the crop for mechanical harvesters. These types of inputs are usually in chemical form, but biological forms of pesticides, including beneficial insects and bacteria, are also used.

Chemicals may be identified by a chemical name or a trade name, usually accompanied by a formulation specifying the rate of active ingredient per gallon. Tank mixes, including some predefined and named mixes of other brand-name chemicals, are commonly used. To simplify pricing, cost reporting, and uses of the information contained in the CAR estimate to address environmental and rotational questions, a detailed listing of brand names, pounds of active ingredient, and chemical formulation (such as wettable powder, granular or aqueous suspension) and concentration is preferred. Notes to a CAR report should contain available information on the potential for chemicals to move off-site, carry over into future production cycles, or create health and safety concerns for the farm operator or employees. To avoid brand names and the implication that a recommendation is being made, generic names and dollar costs may be necessary.

This group of inputs typically can be valued for an individual farm by multiplying quantity of input by its price for projected CAR estimates. Entries for historic CAR estimates either can be calculated in this manner when quantities and prices are known, or the total farm pesticide costs recorded in the record can be allocated to individual crops.

Irrigation

Irrigation systems used throughout the United States and the rest of the world are extremely diverse. Because of their diversity, attempts to generalize about their costs are generally inadequate and incomplete. However, one starting point is to divide systems into two groups based on the source of water: surface or groundwater. Surface water systems, whether from lakes or rivers, usually involve shared ownership of a common resource and an attendant legal system of water rights. Surface water systems also involve structures and delivery systems, many of which are permanently attached to the land, such as earthen and/or concrete-lined ditches, headgates, and other gravity-flow delivery and diversion systems. Groundwater systems usually involve a well, pump, gearhead, and motor as well as permanently attached and/or mechanical discharge and delivery systems. Groundwater systems involve a different system of legal rights, but they do not usually involve shared ownership of a common resource.

Between these two rather simple examples exists a multitude of combinations, including booster pump-pressurized surface water systems, surface water systems with supplemental groundwater wells, and booster pump-pressurized systems that pump from ponds originally filled with either surface, groundwater, animal waste, or municipal sewage sources.

The primary issues involved with allocating irrigation costs to a specific crop are as follows:

1. the original purchase cost of the water resource, if associated with the surface rights, or the water rights if separable from the surface rights;

2. system operating costs, including fuel, lubricants, and repairs for groundwater wells and booster pumps, and labor for all systems;

3. the acquisition and ownership costs associated with permanent improvements and mechanical delivery systems such as sprinklers, gated pipe, and subsurface or surface drip systems; and

4. other water acquisition costs, such as irrigation district taxes, assessments, or maintenance costs.

The first issue is addressed in Chapter 7 on land costs and Chapter 9 on rights to produce, and the second issue is treated in detail in the section on irrigation operating costs in Chapter 5. The third issue is addressed in Chapter 6 on machinery and equipment. The remaining issue is the treatment of costs associated with membership in an organized irrigation district. Irrigation districts are often organized as legal entities with authority to tax water right holders within defined boundaries. These taxes are attached to water rights, which in turn are usually attached to the surface right. Cost and return estimates for crops produced within an irrigation district should identify water district taxes clearly and include the amount in the same fashion as land taxes.

Some irrigation districts will also often charge an annual assessment for water use separately from district taxes. If the district charges a flat fee, the water assessment should be listed as an allocated cost per acre; if a graduated fee or per-water-unit fee is assessed, the water assessment should be identified as an operating cost with the cost per unit and the number of units used reported in the CAR. Other districts do not charge dollar fees to water users, but rather, do require water rights owners to supply labor and/or equipment and materials to maintain common-property ditches, mains, and laterals. Labor and equipment supplied to the district should be valued at opportunity cost in the same manner as other paid or nonpaid labor and machinery. Materials should be valued at cash expenditure value. Labor, equipment, materials, and general district costs not allocable on a per acre-inch basis should be included in the allocated overhead cost section of the CAR.

Miscellaneous Supplies

Miscellaneous supplies for crops include all of the physical (as opposed to financial, insurance, and service-oriented) inputs used in the production of crops, other than the basic inputs discussed previously (especially fertilizers, pesticides, and seeds). Most miscellaneous supplies are purchased and are consumed within one crop production cycle, but some are produced on the farm or as by-products, and some have useful lives that exceed one year (e.g., tree stakes and spreaders, bi-wall drip irrigation tubing, and buckets for hand vegetable harvesting). Typical examples of purchased, annual crop supplies include baling wire and twine, packaging for a roadside stand, or farmers' market produce, and pheromone for insect traps.

The primary issue involved with miscellaneous supplies relates to how the expenditure is reported. Brand names will probably not be used because most miscellaneous crop supplies are more of a generic nature than are chemicals or animal feed additives, for example. If brand names are identifiable and a specific brand name is commonly used, then the brand name could be listed as an identifier. Price and use data can be gathered from local suppliers, farmers, or supply catalogs. Grouping these inputs into a category called "Miscellaneous Supplies" may be preferred due to the nature of these inputs. Because they are miscellaneous, a great amount of detail may be excessive and unnecessary.

INPUTS USED TO PRODUCE LIVESTOCK

Feed

Feed is defined as anything fed to livestock to meet their nutritional needs. Typical feeds include feed grains, forages, minerals, and vitamin concentrates. Modern feeds may also include fat and synthetic amino acid concentrates. Some mixed feeds also include antibiotics fed as growth enhancers. Antibiotics are generally considered feed additives as described below.

Feed is typically the largest cost component in livestock production. Marginal costs of feed per pound of live-weight gain usually increase with animal weight in the range of market weight. Quantity of feed consumed per pound of live-weight gain typically increases with total live-weight. Price per pound of feed may be higher for younger livestock and poultry because they require a higher proportion of protein and other relatively expensive nutrients. Energy is often the least expensive nutrient in the feed.

Cost estimation involves specifying the types, quantities, and prices of feed consumed within the production period. Only the feed that is consumed within the current production period should be counted as feed expense; unconsumed feed should be counted as inventory. Prices and quantities of feed required will vary with the nutrient content of the feed. Quantities and types of feed required will also vary with the age, size, and genetic type of the livestock. There is a wide variety of feeds fed to livestock. As a result, the "average" quantity of feed fed and the "average" price of feed may not be useful in preparing accurate cost estimates for specific operations. Average quantities and average prices adjusted to reflect expected changes in prices of major ingredients may be useful in preparing representative cost estimates for regions or states.

An issue in feed cost calculation is the valuation of feed raised on the farm. Farm-raised feeds should be valued at their opportunity cost as described in Chapter 2.

Example 3. Farm raised feeds.

Consider the example of a farmer producing corn, grain, and hogs, faced with the following data.

Local market price for corn:	$2.10 per bushel
Handling and transportation costs (delivery to the local elevator):	$0.10 per bushel
Net market selling price:	$2.00 per bushel

The net selling price of the grain to the corn production enterprise is thus $2.00 per bushel. Assume that to buy corn for the hog enterprise, the farmer would have to pay $2.10 per bushel to have corn delivered from a neighboring farm and $2.20 to have corn delivered by the local elevator. The cost of the corn to the hog enterprise is the lowest price at which corn can be delivered from off the farm to the hog enterprise, the neighbor's delivered price of $2.10 per bushel for amounts up to that available from the neighbor. ***The Task Force recommends that in this example, the lowest net buying price of corn ($2.10 per bushel) be used as the opportunity cost of corn for the hog enterprise.***

Large transactions costs occur when there is no local market for an intermediate commodity that is very expensive to transport. An example of this situation is a dairy farm that is located far from any source of hay or silage. This dairy farm produces hay for its own consumption. There are no other consumers or producers of hay nearby. As a result, the net market selling price of hay ($55 per ton) is the market price in a distant location ($70 per ton) minus a transportation charge ($15 per ton). The net market buying price of hay ($85 per ton) is the price in the distant market plus transportation costs to the farm. When the farm produces more hay than the dairy herd consumes, it is a net seller of hay and the opportunity cost of this hay to the dairy herd is $55 per ton. If the farm produces only part of the hay required, each ton produced substitutes for a ton of purchased hay and the opportunity cost to the dairy enterprise is $85 per ton. As stated in Chapter 3:

> ***In the case of factors produced and utilized on the farm, the Task Force recommends using the cost of purchasing the factor from off-farm as the cost of the factor to the utilizing enterprise because this reflects the opportunity cost of the factor to the utilizing enterprise.***

Therefore in this case, ***the Task Force recommends the alfalfa hay be valued to the alfalfa enterprise at its net selling price ($55 per ton) and to the dairy enterprise at its net buying price ($85 per ton). This applies the appropriate opportunity cost to each enterprise. The difference of $30 per ton ($85 - $55) is a return to the marketing enterprise or vertical integration in the business.***

Feed Grinding, Pelleting, Mixing, and Handling

Most feed fed to livestock is processed to some extent either on the farm or commercially. The most common on-farm activities are cracking, grinding, and mixing. Many livestock producers will own and operate a tub-grinder, and some larger operations may have an on-farm feed mill. The costs of preparing feed using these capital inputs can be computed using the techniques suggested in Chapters 5 and 6. The costs of the labor used in these operations should also be estimated. All of these feed processing costs should be included as a separate item in cost and return estimates. In many cases the price of commercially prepared and delivered feed includes many of these processing operations. In addition, commercially prepared feeds are often delivered to the farm and in some cases directly to feed bunks or other decentralized locations on the farm. As with the custom application of fertilizer or chemicals, the cost of the feed material should be separated from the processing and handling costs when possible. If there are known efficiencies associated with certain processing operations (pelleted versus ground feed), these should be reflected in the estimated feed requirements and documented in notes to the CAR report.

Feed Additives

Feed additives are defined as material added to feed for purposes other than meeting the basic nutritional requirements of the animal. Common examples of feed additives are feed grade antibiotics fed to enhance the growth of the animal or to treat specific illnesses. Other feed additives may be used to maintain feed quality, reduce dust, or enhance texture and palatability.

Many brand names may exist for a given generic feed additive. The concentration of a particular feed additive may vary across brand names and across products sold by a particular company. Thus, care must be taken in the cost estimation procedure to assure that quantities and prices are compatible. In other respects, including feed additives in CAR estimates is a straightforward selection of price and quantity.

Medicine and Veterinary Supplies

Medicine is defined as any medication not included as a feed additive. Examples include injectable medicines, injectable iron and vitamins, injectable substances used to stimulate estrus, injectable hormones, medication added to drinking water, topical medications and disinfectants, oral medications, and substances to control internal and external parasites. Veterinary supplies are items used to deliver medicine or otherwise maintain the health of the livestock including syringes, needles, blades, disinfectants, and rubber gloves.

Due to the wide variety of inputs included in this category, it may be preferable to establish categories for medicine and veterinary supplies rather than present a detailed listing of individual items. Some records systems, designed to monitor animal health among other herd productivity indicators, distinguish between routine medication (vaccines, iron, and vitamin injections) and occasional treatment for disease.

Breeding Fees and Semen

Costs in this category include materials, semen, and services associated with breeding activities. Breeding fees are fees charged by owners of breeding stock (usually males) for services provided by their animals. This cost category also may include fees charged by owners of females that carry and deliver offspring from implanted fertilized ova owned by another individual. Semen is an operating expense for livestock producers using artificial insemination. The cost of breeding fees and semen will vary greatly with the genetic makeup of the semen donor. Expected fertilization rates also affect the value of semen. Quantity and prices of semen and breeding fees can be collected. Summaries or averages of these data may be separated for those producing breeding animals versus feeders.

Livestock Purchased for Resale

Livestock purchased for resale are defined as animals purchased with the primary intent of selling them at a later date. This generally excludes animals held for breeding and animals held for draft or other purposes. Feeder pigs and feeder cattle are examples of animals commonly purchased for resale. Livestock purchased for resale can be a major expense for feeding enterprises. Thus, the need for accurate cost estimates is obvious, but measuring quantity and prices is complicated by several issues.

Quantity is often described by two variables: number of head and weight per head. There can be substantial variation in the age, size, and quality of livestock purchased for resale. United States Department of Agriculture (USDA) grades can be used as a measure of quality. Most USDA grades are based on the weight and appearance of the feeder animal. Variation in health status and genetic makeup can cause considerable variation in quality within a single grade. As a result, quality is difficult to measure, and, within a grade or other description, average quality usually is assumed.

Prices vary with age, size, and quality. Price per head usually increases with size while price per pound decreases with size. Prices for livestock purchased for resale are dependent on the expected value of the animal at resale and the expected costs of holding the animal until resale including feed, mortality, medicine, facilities, labor, and other expenses. As a result, animals with the characteristics necessary to earn high prices at resale consume less feed to reach resale weight, survive to resale with less medication, occupy facilities for fewer days to resale, and generally incur lower costs to resale will command higher prices at purchase. Thus the price of the animals and the costs and efficiencies included in the CAR estimates must be estimated in a consistent manner.

The procedure for estimating costs of livestock purchased for resale includes measuring total expenditures for livestock associated with the livestock sold. When a group of animals is sold, the expense of purchasing *all* the animals in that group must be charged—including any that may have been purchased with them and died during the feeding period. While the need for this data is usually very clear, it is often difficult to obtain the data on purchases in preparing historical CAR estimates. The approach requires careful record keeping, particularly in operations where many different groups of livestock at different stages are in inventory at any point in time.

Grazing Fees and Pasture Rental Rates

Land used for grazing provides a major source of feed for cattle and sheep. The value of the forage removed or grazed from the land must be included in CAR estimates as a feed item. However, unlike other feed sources, animals are moved to the feed rather than vice versa. The measurement of the amount of forage removed from the land is most difficult. Grazing fees and pasture rental rates usually provide the best estimate of the value of forages removed by grazing.

Federal, state, and private grazing fees and pasture rentals are arranged under a variety of lease arrangements, terms, definitions, and conditions. Federal grazing fees (Bureau of Land Management and U.S. Forest Service) are set on an animal unit month (AUM) basis whereas state trust land fees are charged on a dollar per acre, dollar per head, and dollar per AUM basis in various states. Animal units (AU) are a classification system devised to indicate pasture carrying capacity and consumption of forages by various classes of animals. Animal unit definitions can vary but the current scientific studies generally support animal unit computations based on daily forage intake of 2% of body weight for ruminants and 3% of body weight for nonruminants, normalized to a 1.00 animal unit base for a 1,000-pound beef cow. The AU equivalent for various sizes of roughage-consuming animals is shown in Table 4.1. To use this procedure, consider a 1,400-pound bull. At 2% of body weight, the bull is expected to consume 28.0 pounds of dry- matter per day. Normalizing by the cow's 20.0 pound daily consumption, the bull is considered equivalent to 1.40 AU.

An AUM is the amount of feed needed to support one AU for one month. A 1,000-pound cow requires 20 pounds of dry-matter intake daily and 600 pounds over a 30-day month. A 1,400-pound bull would need 840 pounds (600 x 1.4). This approach is used to estimate the number of animals a range or pasture can support by estimating the forage production and converting the result to AUMs.

The rates charged to lease private pasture are expressed in a variety of ways. The methods of expressing the lease rate for private forage leases include total lease price, dollars per acre, dollars per head, dollars per AUM, dollars per year or grazing season, dollars per pound of gain, and dollars per pound in-weight to the pasture. Also, services (e.g., care of cattle, use of facilities, checking water) may or may not be provided by the lessor and the services provided greatly affect the lease price. The operating condition and requirements can vary also; these include minimum residue requirements, on- and off-dates, total numbers, and range maintenance. The final method, which may well be the most commonly used method, is that private pasture is grazed by the owner's livestock and no fee is charged. Footnotes should be used to specify these details regardless of whether individual or aggregate CAR estimates are being prepared. A more detailed discussion of grazing rights and grazing fees is contained in Chapter 9: Joint Costs, General Farm Overhead, and Rights to Produce.

TABLE 4.1 Daily Dry-matter Consumption by Various Animals Based on Their Body Weight

Animal	Weight	Daily Dry-Animal Matter Intake	Daily Dry-Matter Intake	Animal Unit Equivalents
	lbs	% of weight	lbs	AU
Cattle (mature)	1,000	2	20.0	1.00
Cattle (yearling)	750	2	15.0	0.75
Sheep	150	2	3.0	0.15
Goat	100	2	2.0	0.10
Horse	1,200	3	36.0	1.80
Donkey	700	3	21.0	1.05
Bison	1,800	2	36.0	1.80
Elk	700	2	14.0	0.70
Moose	1,200	2	24.0	1.20
Bighorn sheep	180	2	3.6	0.18
Mule deer	150	2	3.0	0.15
White-tailed deer	100	2	2.0	0.10
Pronghorn antelope	120	2	2.4	0.12
Caribou	400	2	8.0	0.40

Source: Holechek et al.

Leased Forage

The most common methods of stating the price for private leases are either dollar per acre or dollar per AUM. Either of these charge methods is logical and can be used successfully if the units are well defined and understood. Other charge methods, such as dollars per pound of gain, do not lead to an autonomously set fee; the actual fee cannot be determined until the average rate of gain is known or estimated. It is also unclear how to convert a gain-based fee to a dollar per AUM or acre basis.

The most important issue in pasture rental rates is to understand and define clearly the units used in setting the lease price. It also is important to state the terms of the rental agreements clearly to avoid misinterpretation. Rates are typically quoted as dollars per unit, dollars per acre, or total dollars. Consider first the case of dollars per unit.

Dollars Per Unit of Livestock. Several options are available for estimating grazing fees on any of the dollars per unit bases. Each of these methods has distinct advantages for range management relative to others or to non-unit-based grazing fees or pasture rental rates. However, the method selected in developing CAR estimates should reflect actual practice rather than some theoretical construct. For example, the method selected should depend upon the practice used between lessee and lessor for a specific farm, or common practices for representative farms, or average practices for more highly aggregated production situations.

The methods of measuring the costs associated with leased forage relate primarily to collection of market rental rates and appropriate additional costs for livestock and/or pasture management services not included in the rental rate or grazing fee. Measurement methods include the following three systems.

1. *Dollars per head or AUM.* Animal unit equivalency factors used to convert to AUMs have not been standardized, but it is most common to count only animals over six months of age. It is important to state the equivalency factor that was used. For example, if yearling cattle are part of the lease, was each yearling counted as equivalent to 1 AU or was some other equivalency such as 0.75 used?

2. *Dollars per pound of gain*. This type of lease arrangement is the least informative because the cost of the lease is not known until after the grazing period when livestock are sold.

3. *Dollars per hundredweight entering the pasture*. The procedure must clearly define the number of head and weight of animals entering the pasture.

The strength of dollars per unit cost systems is that stocking rates, consequent fixed resource use, and other input use can be measured on the same basis as the output is measured. As a result, updates, revisions, and projections can be made rather easily; comparisons between grazing systems assuming differing stocking rates or comparisons among geographic areas or grazing systems can also be made easily and efficiently. The primary weakness of these methods is the increased complexity of the data collection.

A simpler way to compute grazing costs is to measure them in dollars per acre and assume some type of standard stocking rate.

Dollars Per Acre. To avoid at least some of the complexity, definition, and data collection issues, an estimate of dollars per acre could be included either as a return for a crop (either pasture, preseason, or crop aftermath) grazing activity or as a cost for a livestock activity. Calculating lease rates on a dollar per acre basis is perhaps the least ambiguous, but problems still arise when the lease includes state and federal rangeland. The question arises as to whether the number of acres included in the lease price should include only deeded acres or all acres in the pasture.

The primary advantage of this method is simplicity of definition, programming, and data collection, but it sacrifices the variable nature of stocking rates and clouds cost/return changes in intertemporal and spatial comparisons as the components (use and value per grazing unit) are subsumed into a total. The dollars per acre method could be used quite successfully, though, especially for crop aftermath grazing of such crops as corn stalks, cotton stubble or post-frost alfalfa in which little more than livestock maintenance is expected.

The easiest and least accurate method is total dollars.

Total Dollars. This procedure uses a single total dollar amount for pasture leases or grazing fees. Stating the total cost of the lease clearly defines how much was paid but it does not provide all information as to the basis for this charge. The main advantages of this system are simplicity and direct data collection and verification with farm records.

Raised Forage

Placing a value on forage produced on the farm or ranch for consumption by owned livestock, as opposed to forage leased to or from a separate source, is similar to the problem of valuing farm-raised grain or hay fed to livestock. One alternative is to evaluate the livestock-pasture combination as one enterprise.

If separation of enterprises is required, the Task Force recommends that the net selling price be used to value the forage to the pasture enterprise and the net market buying price be used to value forage used by the livestock.

A limitation that must be recognized is that average market prices for unharvested forage typically include the value of services provided by the lessor of the forage, such as fencing, watering facilities, and labor to care for livestock. Adjustments must be made to value only the forage or to include appropriate livestock management or pasture management costs.

Miscellaneous Supplies

This final category is used to capture livestock operating expenses that have not been included elsewhere. Examples include ear tags for identification, batteries for electric prods and fences, markers, and disposable plastic boots. The challenge associated with this category is to ensure that inputs assigned to this category have not been included in a previous category.

CHAPTER 5

MACHINERY, EQUIPMENT, AND BUILDINGS: OPERATING COSTS

INTRODUCTION

Types of Costs Associated with Machinery, Equipment, and Buildings

The ownership and use of machinery, equipment, and buildings leads to a variety of costs. During a given production period, the owner of these assets incurs costs associated with (1) holding each asset over the period (including opportunity interest), (2) service reduction due to use and time, (3) changes in the implicit value of the assets' services, (4) maintenance, (5) service enhancement, and (6) the passage of time such as property tax and insurance. In Chapter 2 these costs were summarized using equation 2.25 as follows:

$$\begin{aligned} \textit{Total capital service cost} = \; & \textit{Opportunity cost} \\ & + \textit{service reduction cost} \\ & + \textit{change in price of the capital asset's service capacity} \\ & + \textit{maintenance cost} \, (+ \textit{service enhancement cost}) \\ & + \textit{other time costs}. \end{aligned}$$

Service enhancement costs are in parentheses because they are usually handled in conjunction with service reduction costs or the price change adjustments. Expenditures for maintenance and other time costs often involve the use of expendable inputs such as lubricants, parts, hired services, or operator labor. Thus they are often estimated in conjunction with other operating costs such as seed, fertilizer, and supplies. Costs associated with machinery, equipment, and buildings—such as opportunity interest and changes in service capacity or price—are often implicit and/or accrue over the life of the asset. Chapter 6 on durables addresses these costs, whereas this chapter specifically discusses the operating costs associated with machinery, equipment, and buildings.

Determining Input-Output Relationships for Machinery, Buildings, and Equipment

As discussed in Chapter 2, capital assets are one of the types of inputs used in the production of agricultural output. In assessing the cost of using alternative capital assets, it is useful to determine the output per unit of input in order to assess the productivity of alternative production systems. If the production system is of the Leontief type with fixed coefficients, then the output associated with a given asset is also fixed. In this case, the cost per unit of input can be used to compute the cost per unit of output using the constant technical coefficients. For example, if it is assumed that sweet corn production in central Washington uses 2.77 hours of tractor time per acre and the total cost per hour for using the tractor is computed to be $23.80

with yields per acre of 9.5 tons, the cost per ton for the tractor is [(2.77)(23.80)/(9.5)] = $6.94. This assumes that an hour of tractor time has the same productivity regardless of the tractor age or use per year. If the service output for the tractor varies with age or use, a more complicated procedure as discussed in Appendix 6A is needed. In analyzing operating costs associated with machinery, equipment, and buildings in this chapter, it will be assumed that it is reasonable to compute cumulative maintenance and other operating costs for these items based on total lifetime hours of use and then to convert these to a constant real cost per hour (day, year, etc.) of equally productive service, regardless of when that service is used within the economic life of the asset.

MACHINERY OPERATING COSTS

Methods to Estimate Machinery Operating Costs

There are two major methods of determining machinery operating expenses: producer surveys and direct estimation using equations based on survey information. Surveys of individual farms are generally used to calculate the costs and returns (CARs) of a specific commodity on a specific farm given the cropping mix and machinery set used on that farm. Where possible, surveys request producers to estimate machinery costs for an enterprise. Many producers, however, do not have adequate enterprise records to identify costs by enterprise. When producers do not have adequate records, it is necessary to allocate whole-farm costs to the individual enterprises. The allocation of whole-farm data to a specific enterprise is carried out in a variety of methods. These include percentage allocations by each producer, allocations based on machinery use on each enterprise, and allocations based on predetermined formulas. More discussion of these allocation issues is contained in Chapters 6 and 9.

Direct estimation of machinery operating costs utilizes previously estimated engineering equations. Costs are estimated using typical machinery hours, age, size, and type. This information is usually based on expert opinion, a consensus of selected producers, or a producer panel. Equations developed by agricultural engineers and economists are then used to calculate typical costs for production in a specific region taking into account typical machine usage and variations in the machinery complement used. The survey method and engineering method are not mutually exclusive and are sometimes combined. For example, surveys may be used to collect data on machinery use and size, which are then used with engineering equations to calculate costs. Engineering equations are also used with the survey method as a means of allocating whole- farm costs to specific enterprises. A disadvantage of engineering equations is that they do not fully account for unique farm characteristics such as the level of management. The level of management can impact machinery costs significantly, and can be important when making comparisons between a farm and regional averages.

The selection of which method or combination of methods to use in determining machinery repair or fuel use depends on a number of factors. Of major importance is the intended use of the cost estimates. The survey method is generally preferred when actual farm-level cost data are required. Actual farm-level cost data are often required when the estimates are used for policy analysis and program administration purposes. Policy analysis often examines the variability in returns and how different policies may impact different groups of farms by size and other variables. Policy analysis related to farm income issues is generally concerned with historical CARs that are best estimated with the survey method. In program administration and program evaluation, actual data from individual farms are often needed, thereby making the survey approach the most appropriate. However, even in the "Agricultural Resource Management Study" (formerly FCRS) conducted by the United States Department of Agriculture (USDA) Economic Research Service (ERS), total farm costs must be disaggregated by proportioning machinery costs to particular enterprises and, if needed, to particular field operations. This allocation is often accomplished using equations originally published by Bowers and Hunt. Another potential benefit of the survey method is that it permits farmers to compare their results against those of a group of farmers in a similar region.

Some uses of CAR estimates encompass situations where it is desirable to estimate machinery costs using engineering equations, such as when CARs are being projected for a specified farm organization on a typical or representative farm in a region. In other cases, such as for new machinery, survey information may not be available, making it necessary to use engineering equations. Engineering equations may be most appropriate for technology assessments which call for potential changes in machinery complements. Also, the equations are particularly useful for making quick comparisons between machinery alternatives for accomplishing a selected task.

In addition to the uses of the CAR estimates, there are a number of other factors one must consider in developing these estimates. Of importance are the resources which are available. The survey method has a disadvantage compared to the use of equations in that it can be expensive in both dollars and human resources required and the results obtained are tied to a point in time. Surveys are time consuming, making it difficult to have information available on a timely basis. Other problems such as sampling and nonsampling errors can impact the results of the survey approach. The engineering approach generally is inexpensive and does not require a large time commitment. A disadvantage of the engineering approach is that some of the engineering equations have not recently been updated, which may impact the accuracy of the results. However, because the equations often use machine list price as a parameter, the cost estimates can be adjusted for time by updating list price, fuel price, and so forth. There is and will continue to be an ongoing debate about which is more accurate and appropriate—survey or direct machinery cost estimation.

In comparing estimates from different sources, it is important to know which methods were used in calculating the costs. Direct comparisons between estimates based on the survey approach and the engineering approach are not possible. The most appropriate method to use will depend largely on the use of the estimates. Whatever method is used, information on how the costs are estimated must be provided to the potential user. For the survey method it is important to specify how, when, and where costs were collected and calculated. If whole-farm costs were allocated to a specific commodity, the allocation method should be reported. The collection of whole-farm data in the survey method is recommended even if allocations are not made on whole-farm costs. Whole-farm costs, at the very least, provide a useful check to verify commodity-specific costs. If engineering equations are used, details about the machinery complement and farm machinery use should be specified.

Chapter 5. Machinery, Equipment, and Buildings: Operating Costs

Using Surveys to Estimate Machinery Operating Costs

Surveying farmers to elicit their machinery operating costs by enterprise is a challenging task because most farmers do not maintain records for this purpose. Farmers usually only record income and expense information. To determine enterprise costs, either additional information necessary to allocate expenses to each enterprise of interest must be obtained, or machinery costs for each enterprise must be elicited directly.

The first method of surveying machinery costs assumes that costs of machinery operation are available at the farm level. Expenses for fuel, lubrication, repairs, and so forth for the entire unit can usually be obtained from farm account books, income tax returns, or other financial statements. In addition, information necessary to allocate the farm-level costs to the enterprises of interest must also be elicited. The additional information may either be objective data, such as acres of various crops and units of livestock, or various subjective factors, such as the operator's assessment of enterprise shares. If the producer does not have or remember detailed information on tillage operations associated with each activity, then estimation based on machine operations may be difficult. The use of a tableau similar to Figure 5.1 and /or the one discussed in detail in Chapter 9 may be helpful in the subjective allocation of machine time and machine costs.

The purpose of the top half of the tableau is to help the farm operator recall the acreages and machine operations associated with each enterprise. The operator may not be able to fill in all the information, but the more complete the information, the better will be the allocated estimates in the bottom half of the tableau. The top half may also be useful in determining the machine operations that are analyzed using engineering equations. Total farm expenses for fuel, lubrication, and repairs would then be entered in the whole-farm column. This data could come from available records and operator estimates of labor time involved in on-farm repairs. Repair expenses would then be allocated between tractors, combines, and implements (if possible), still in the whole-farm column. The purpose of allocating the repair expenses is to determine which types of equipment have the most repairs. Total fuel, lubrication, and repairs could then be allocated across enterprises. For example, on a Great Plains small grain farm, fuel costs for wheat and barley enterprises may each be estimated by the farm operator to be 50% of whole-farm expenses. Or, on an Idaho alfalfa and barley operation with 50% acreage in each crop, the allocation of repairs may be 65% to the alfalfa and 35% to the barley due to high repair costs for haying equipment. The column expense total could then be used in an enterprise-specific CAR.

An alternative to a subjective allocation by the producer, researcher, or farm management consultant is the use of a regression equation similar to

$$y_t = \beta_0 + \beta_1 x_{1t} + \beta_2 x_{2t} + e_t \qquad \textbf{(5.1)}$$

to estimate each enterprise share. The dependent variable y_t represents the total farm-level cost for an item such as fuel for the t^{th} farm in the sample, whereas the independent variables x_{1t} and x_{2t} represent different farm enterprises (usually measured in acres produced). For example, there may be different crops on a grain farm, or acres of crops and units of livestock on a combined crop/livestock farm. The coefficients of each variable are then interpreted as the respective cost of each unit. The intercept value $ß_0$ is defined to be the whole-farm level cost that is unallocated to each enterprise. Use of this method does require variation in costs and enterprise quantities among farms.

Figure 5.1 Allocation of Machine Costs for a Crop Producer

Item	Whole-Farm	Enterprise 1	Enterprise 2	Enterprise n
Total Acres				
Acres plowed				
Acres disced				
Acres harrowed				
Acres planted with planter				
Acres planted with drill				
Acres baled				
etc.				
Total fuel expense				
Total lubrication expense				
Total repair costs				
Repairs on tractors		X	X	X
Repairs on combines		X	X	X
Repairs on balers		X	X	X
Repairs on planters		X	X	X
etc.		X	X	X
TOTAL EXPENSE	Total Farm	Tot. Ent. 1	Tot. Ent. 2	Tot. Ent. n

Notes: (1) The top half of the table is completed first.
(2) The whole-farm column in the bottom half is completed next.
(3) The allocations across enterprises for total fuel, lubrication, and repairs is completed last. Boxes with X are not filled in.

The second method for obtaining machinery operating costs is to use a direct survey. However, these procedures are more complex. Past efforts have ranged from asking farmers to specify each component of cost directly to observing each farmer's actual usage of the resource involved. Asking farmers directly to report fuel costs per acre or repair costs per head of livestock can be efficient from the researcher's perspective because only minimal effort must be expended for data collection. However, the data obtained must be reviewed carefully to ensure that the farmers understand what is being asked of them and that the estimates obtained are accurate. To assist farmers with this process, various logs can be devised to aid and remind them of the data collection process. The underlying data to support estimation of the agricultural engineering equations described later were originally collected by this method. Observing farmers' direct usage of resources is far more time consuming but removes any errors associated with farmers' direct reporting of the costs. In either of these procedures, results and significance of the analysis are conditional on the sampling levels and methods employed.

Using Equations to Estimate Machinery Operating Costs for Crop Enterprises

Field operations to be performed and the set of machines to be used must be specified before costs can be estimated using engineering equations. Accurate specification of machinery costs using equations requires that the following steps be performed.

Farm Specification

Items required to identify the farm include (a) number of acres of each crop to be grown, and (b) machine operations on each crop, including time period (month or week) of execution. Machinery operating costs per acre typically do not vary much based on the size of machine as long as the implements and tractors are fairly well matched. However, the ownership costs can vary substantially depending on the size and annual use of equipment. Farms specializing on one crop may use farm equipment intensively for short periods of time, but may use the equipment relatively few hours per year causing ownership costs per acre to be high relative to diversified farms where machinery can be used on several crops over numerous time periods.

Machinery Selection

The set of machinery selected for a farm must be capable of performing all required tasks in a timely fashion. Also, it would be desirable to have a complement that can provide the required services for relatively low ownership costs. Developers of CAR estimates using machinery cost equations should always check the feasibility of the machinery complement being considered. This may involve something as straight forward as identifying the time period (month or week) where it appears that the greatest demands are being placed on the machinery complement and then determining the hours of use for each machinery item. Tractor hours are probably the most critical in terms of excess use. One tool for checking the feasibility of a machinery complement is found in Kletke and Sestak where a spreadsheet template (MACHSEL) is used for checking the feasibility of a complement and estimating the expected costs for a complement given any particular farm situation. The greatest difficulty with this kind of template and the engineering equations in general is the amount of information that must be provided about the farm, the farm organization, and the machinery to be used. (See also the last section of Chapter 6).

Engineering Equations for Estimating Machinery Repair Costs per Hour of Use

The American Society of Agricultural Engineers (ASAE) publishes procedures for estimating the costs to own and operate farm machinery. These procedures have been revised several times over their 40-year history. The latest procedures are given in the 1997 ASAE Standards[1]. The functional forms for cost estimation have changed over the years as well as the repair coefficients and length of life as machinery technology has improved. Rotz and Bowers give a good summary of the changes that have taken place in the engineering equations over time. These procedures have evolved from their start in the late 1920s and '30s. In 1966 it was suggested that repair and maintenance costs be estimated as a function of machine age expressed as a percent of lifetime service hours.

$$AR = (RF1)(X)^{RF2} \qquad \textbf{(5.2)}$$

where

AR	=	accumulated repair and maintenance as a percent of list price
X	=	accumulated use as a percent of lifetime hours
RF1, RF2	=	repair factors.

Note that AR is a percentage that must be multiplied by the list price to obtain total accumulated repairs and maintenance. In the late 1960s and early '70s the equations were changed after several studies were completed on machinery repair costs. The following equation was developed from work by Bowers and Hunt.

$$TAR = (LP)(RP1)(RP2)(X)^{RP3} \qquad \textbf{(5.3)}$$

where

TAR	=	total accumulated repairs and maintenance (dollars)
LP	=	list price (dollars)
X	=	accumulated use as a percentage of lifetime hours ($0 \le X \le 100$)
RP1	=	repairs over useful life as a proportion of list price ($RP1 \ge 0$)

[1] Standards: ASAE S495 (Dec 94), Uniform Terminology for Agricultural Machinery Management; ASAE Engineering Practice: ASAE EP496.2, Agricultural Machinery Management (Mar 94); ASAE Data: ASAE D497.3, Agricultural Machinery Management Data (Nov 96).

RP2, RP3 = paired constants providing shape to repair curve.

The coefficients RP2 and RP3 come in pairs which shape the distribution of repairs over the life of the machine. The coefficient RP1 is defined by $\frac{TAR^*}{LP}$ where TAR* is the value of equation 5.3 when the machine is at the end of its useful life. If h denotes accumulated hours of use and LIFE = total machine lifetime (hours), then $X = \frac{(h)(100)}{LIFE}$. When h = LIFE, then X = 100. Using this information we can define the relationship between RP2 and RP3 by evaluating 5.3 with h = LIFE. Specifically,

$$TAR^* = (LP)\frac{(TAR^*)}{LP}(RP2)\,(100)^{RP3}$$
$$\Rightarrow 1 = RP2\,(100)^{RP3}$$
$$\Rightarrow RP2 = \left(\frac{1}{100}\right)^{RP3}.$$

When working with the Bowers and Hunt repair equation, the RP2 and RP3 pairs reported in Table 5.1 must be used. The purpose of the pairs of coefficients is to allocate repairs over the life of the machine. The function of RP2 and RP3 is to shape the repair cost curve. The total expected repairs over the lifetime of the machine as a proportion of the initial list price is given by the Bowers and Hunt RP1 factor and so long as RP1 does not change, the total repairs over the life of the machine will not change no matter which set of RP2 and RP3 is used. As the RP3 factor (second column in Table 5.1) increases, repairs are moved towards the end of machine life. When the first pair of coefficients (.01 and 1.0) is used, repairs occur linearly over the life of the machine.

In 1977, a major change occurred in the equations. They were converted from three repair factors (RPi) to two repair factors (RFi) by expressing machine age in thousands of hours rather than as a percent of lifetime hours. In 1987, Rotz created an even more generic model that was adopted by the ASAE Standards Committee. This model is the standard in the latest ASAE publications. This accepted model is

$$C_{rm} = (RF1)(P)\left(\frac{h}{1{,}000}\right)^{RF2} \qquad \textbf{(5.4)}$$

where

C_{rm}	=	total accumulated repair and maintenance (dollars)
P	=	machine list price in current dollars
h	=	accumulated use (hours)
RF1, RF2	=	repair and maintenance factors.

The exponent (RF2) in equation 5.4 is the same as the exponent (RP3) in equation 5.3. The prices P and LP are also the same. The relationship between the other variables can be found by setting TAR = C_{rm} and using the fact that RP3 = RF2 and P = LP.

$$TAR = (LP)(RP1)(RP2)\left(\frac{(h)(100)}{LIFE}\right)^{RP3} = (LP)(RF1)\left(\frac{h}{1{,}000}\right)^{RP3} = C_{rm}.$$

By solving for RF1 as follows:

$$\begin{aligned}
(LP)(RP1)(RP2)\left(\frac{(h)(100)}{LIFE}\right)^{RP3} &= (LP)(RF1)\left(\frac{h}{1{,}000}\right)^{RP3} \\
\Rightarrow (RP1)(RP2)\left(\frac{100}{LIFE}\right)^{RP3} &= (RF1)\left(\frac{1}{1{,}000}\right)^{RP3} \\
\Rightarrow (RP1)(RP2)(100)^{RP3}\left(\frac{1{,}000}{LIFE}\right)^{RP3} &= RF1,
\end{aligned}$$

and, since $RP2(100)^{RP3} = 1$ it is determined that

$$(RP1)\left(\frac{1{,}000}{LIFE}\right)^{RP3} = RF1.$$

In summary, equation 5.4 (Rotz equation) is related to equation 5.3 (Bowers and Hunt equation) in the following manner.

Bowers and Hunt	Rotz
TAR	C_{rm}
LP	P
(RP1) $(1{,}000/LIFE)^{RP3}$	RF1
RP3	RF2

For those who want to use the Bowers and Hunt three-factor equations, the Rotz RF2 can be used to calculate the Bowers and Hunt RP2 as follows:

$$RP2\,(Bowers\ \&\ Hunt) = \frac{1}{100^{RP3(Bowers\ \&\ Hunt)}} = \frac{1}{100^{RF2(Rotz)}}. \qquad \textbf{(5.5)}$$

The Rotz equations do not allow users to control the way repair costs occur over the life of the machine as do the Bowers and Hunt equations. They also do not allow the user to specify what repair costs are expected to be over the life of the machine. Lifetime repairs as a proportion of list price can be obtained from the relationship $RP1 = RF1\left(\frac{LIFE}{1{,}000}\right)^{RF2}$. Because useful life is implicit in the Rotz equations, it is possible to obtain the RF1 values in Table 5.2 using information on useful life, lifetime repairs as a proportion of list price, and RF2. For the first tractor in Table 5.2 with lifetime repairs equal to 100% of list price, repairs as a portion of list price are

$$
\begin{aligned}
RF1 &= (1)\left(\frac{1{,}000}{12{,}000}\right)^{2} \\
&= .00069\overline{4} \\
&\approx .0007 .
\end{aligned}
$$

TABLE 5.1 Paired Values for Repair and Maintenance Coefficients RP2 and RP3 where $RP2 = \frac{1}{100^{RP3}}$

RP2 (Bowers & Hunt)	RP3 (Bowers & Hunt) or RF2 (Rotz)
.0100000	1.0
.0063096	1.1
.0039811	1.2
.0025119	1.3
.0015849	1.4
.0010000	1.5
.0006310	1.6
.0002512	1.7
.0001585	1.9
.0001000	2.0
.0000631	2.1
.0000398	2.2
.0000251	2.3

In summary, the Rotz equations are easier to apply because only hours of use and list price are necessary to estimate the accumulated repairs. What is given up for this simplicity is the ability to vary total expected life (LIFE) and the amount of repairs expected over the life of the machine (Bowers & Hunt RP1). If users are willing to give up control of these parameters, then the Rotz equations are a useful simplification. However, because of the wide diversity in climate, variation in field conditions, and perhaps perceived differences in quality of workmanship in machine manufacture, the older Bowers and Hunt equations can be used because they will give identical results given the same assumptions while allowing more flexibility for users who want it.

In 1991, Rotz and Bowers revised the repair factors (RF1, RF2) for some types of machinery. Estimated life was increased for tractors, planting equipment, and self-propelled harvesting equipment and decreased for beet harvesting equipment and forage blowers. They also reduced the repair factors for selected machinery. These changes are included in the current ASAE Standards (ASAE D472.3 NOV 96, Table 3) and are summarized in Table 5.2.

The ASAE repair and maintenance procedure is designed to estimate all of the costs associated with repair and maintenance. These include all replacement parts, materials, shop expenses, and labor. Work done at a machinery dealership includes all of these costs. Repair work done on the farm should include a cost for the farmer's labor as well as a cost for maintaining a shop. Repair and maintenance costs are highly variable and unpredictable as to time of occurrence. Actual repair and maintenance costs vary widely with standard deviations likely exceeding the mean cost.

The ASAE equations are useful for predicting the average costs for repair and maintenance over the life of the machine. These equations have been used to estimate costs that occur during a relatively short period (one or two years), but it is not a recommended practice. Also, they should not be used to estimate repair and maintenance costs for machinery used beyond the estimated life of the machine. For machines used beyond their estimated hours of life, agricultural engineers recommend using the repair and maintenance cost estimated for the last year of expected life.

Converting Costs per Hour to Costs per Acre Using ASAE Standards

Field Performance

Field performance is needed to convert machinery costs per hour to a per acre or per unit basis. There are two methods for estimating performance. The first alternative is to obtain an estimate from the producer based on past experience. The second alternative is to use engineering equations to estimate field performance. For estimating costs of a specific field operation for a given producer, the first alternative is preferred. When producer estimates are not available, or when a typical or average measure is required, the second alternative can be used.

Estimating costs on a per acre basis requires knowledge of the effective field capacity of implements and self-propelled equipment. Effective field capacity is expressed as acres per hour for some machines (for example, plows and planters) or tons per acre for others (for example, balers and forage harvesters). The effective field capacity is estimated from the field speed, implement working width, field efficiency, and unit yield of the field for a given piece of machinery. Field speed is the average speed at which the functional work will be done in the field. For example, a farmer might average 4 mph plowing when the plow is actually in the soil. Implement working width is the measured width of the working portion of the machine. For example, for a planter it is the average row width times the number of rows. The ratio of effective field capacity to theoretical field capacity is the field efficiency of a machine. The field efficiency is expressed as a percent and is used to account for a number of factors that influence field operations, including failure to utilize the theoretical operating width of the machine, time lost turning, operator habits, field characteristics, and so forth. Travel to and from a field, repairs and maintenance, and daily service activities are not accounted for in the field efficiency coefficient.

Calculated area capacity is computed as follows:

$$C_a = \frac{(S)\,(W)\left(\frac{E_f}{100}\right)}{8.25} \tag{5.6}$$

where

C_a	=	acres per hour calculated capacity
S	=	implement speed in miles per hour
W	=	measured width of the implement in feet
E_f	=	field efficiency, the ratio of effective accomplishment compared to theoretical accomplishment, expressed in percent
8.25	=	43,560 (square feet per acre) divided by 5,280 (feet per mile) = width of acre 1 mile long.

Example: One of the machines used on the Ben and Bev Dairyman Farm is a 19′ tandem disk. Ben estimates that he normally travels six miles per hour when disking. Table 5.2 indicates that a disk normally operates at about 80% efficiency because of turning, and in-field travel time. Given this information the expected acres planted per hour is

$$C_a = \frac{(6.0)(19.0)\left(\frac{80}{100}\right)}{8.25} = 11.0545\ acres/hour\,.$$

The amount of product yield is used to estimate capacity for machinery such as balers that do not cover each square foot of the field. Calculated material capacity is computed as follows:

$$C_m = \frac{(S)(W)(Y)\left(\frac{E_f}{100}\right)}{8.25} \qquad \textbf{(5.7)}$$

TABLE 5.2 Field Efficiency, Field Speed, Estimated Life, Total Life Repair Cost, and Repair Factors for Selected Machinery

Machine	Field Efficiency Range %	Field Efficiency Typical %	Field Speed Range mph	Field Speed Typical mph	Field Speed Range km/h	Field Speed Typical km/h	Estimated Life h	Total Life R&M Cost % of List price	Repair Factors RF1	Repair Factors RF2
TRACTORS										
2 wheel drive & stationary							12,000	100	0.007	2.0
4 wheel drive & crawler							16,000	80	0.003	2.0
TILLAGE & PLANTING										
Moldboard plow	70-90	85	3.0-6.0	4.5	5.0-10.0	7.0	2,000	100	0.29	1.8
Heavy-duty disk	70-90	85	3.5-6.0	4.5	5.5-10.0	7.0	2,000	60	0.18	1.7
Tandem disk harrow	70-90	80	4.0-7.0	6.0	6.5-11.0	10.0	2,000	60	0.18	1.7
(Coulter) chisel plow	70-90	85	4.0-6.5	5.0	6.5-10.5	8.0	2,000	75	0.28	1.4
Field cultivator	70-90	85	5.0-8.0	7.0	8.0-13.0	11.0	2,000	70	0.27	1.4
Spring tooth harrow	70-90	85	5.0-8.0	7.0	8.0-13.0	11.0	2,000	70	0.27	1.4
Roller-packer	70-90	85	4.5-7.5	6.0	7.0-12.0	10.0	2,000	40	0.16	1.3
Mulcher-packer	70-90	80	4.0-7.0	5.0	6.5-11.0	8.0	2,000	40	0.16	1.3
Rotary hoe	70-85	80	8.0-14.0	12.0	13.-22.5	19.0	2,000	60	0.23	1.4
Row crop cultivator	70-90	80	3.0-7.0	5.0	5.0-11.0	8.0	2,000	80	0.17	2.2
Rotary tiller	70-90	85	1.0-4.5	3.0	2.0-7.0	5.0	1,500	80	0.36	2.0
Row crop planter	50-75	65	4.0-7.0	5.5	6.5-11.0	9.0	1,500	75	0.32	2.1
Grain drill	55-80	70	4.0-7.0	5.0	6.5-11.0	8.0	1,500	75	0.32	2.1
HARVESTING										
Corn picker sheller	60-75	65	2.0-4.0	2.5	3.0-6.5	4.0	2,000	70	0.14	2.3
Combine	60-75	65	2.0-5.0	3.0	3.0-6.5	5.0	2,000	60	0.12	2.3
Combine (SP)*	65-80	70	2.0-5.0	3.0	3.0-6.5	5.0	3,000	40	0.04	2.1
Mower	75-85	80	3.0-6.0	5.0	5.0-10.0	8.0	2,000	150	0.46	1.7
Mower (rotary)	75-90	80	5.0-12.0	7.0	8.0-19.0	11.0	2,000	175	0.44	2.0
Mower-conditioner	75-85	80	3.0-6.0	5.0	5.0-10.0	8.0	2,500	80	0.18	1.6
Mower-conditioner (rotary)	75-90	80	5.0-12.0	7.0	8.0-19.0	11.0	2,500	100	0.16	2.0
Windrower (SP)	70-85	80	3.0-8.0	5.0	5.0-13.0	8.0	3,000	55	0.06	2.0
Side delivery rake	70-90	80	4.0-8.0	6.0	6.5-13.0	10.0	2,500	60	0.17	1.4
Rectangular baler	60-85	75	2.5-6.0	4.0	4.0-10.0	6.5	2,000	80	0.23	1.8
Large rectangular baler	70-90	80	4.0-8.0	5.0	6.5-13.0	8.0	3,000	75	0.10	1.8
Large round baler	55-75	65	3.0-8.0	5.0	5.0-13.0	8.0	1,500	90	0.43	1.8
Forage harvester	60-85	70	1.5-5.0	3.0	2.5-8.0	5.0	2,500	65	0.15	1.6
Forage harvester (SP)	60-85	70	1.5-6.0	3.5	2.5-10.0	5.5	4,000	50	0.03	2.0
Sugar beet harvester	50-70	60	4.0-6.0	5.0	6.5-10.0	8.0	1,500	100	0.59	1.3
Potato harvester	55-70	60	1.5-4.0	2.5	2.5-6.5	4.0	2,500	70	0.19	1.4
Cotton picker (SP)	60-75	70	2.0-4.0	3.0	3.0-6.0	4.5	3,000	80	0.11	1.8
MISCELLANEOUS										
Fertilizer spreader	60-80	70	5.0-10.0	7.0	8.0-16.0	11.0	1,200	80	0.63	1.3
Boom-type sprayer	50-80	65	3.0-7.0	6.5	5.0-11.5	10.5	1,500	70	0.41	1.3
Air-carrier sprayer	55-70	60	2.0-5.0	3.0	3.0-8.0	5.0	2,000	60	0.20	1.6
Bean puller-windrower	70-90	80	4.0-7.0	5.0	6.5-11.5	8.0	2,000	60	0.20	1.6
Beet topper/stalk chopper	70-90	80	4.0-7.0	5.0	6.5-11.5	8.0	1,200	35	0.28	1.4
Forage blower							1,500	45	0.22	1.8
Forage wagon							2,000	50	0.16	1.6
Wagon							3,000	80	0.19	1.3

*SP indicates self-propelled machine.

where

C_m	=	tons per hour calculated capacity
S	=	implement speed in miles per hour
W	=	effective width of the implement in feet
Y	=	unit yield of the field in tons per acre
E_f	=	field efficiency, the ratio of effective accomplishment compared to theoretical accomplishment expressed as a percentage (so that dividing by 100 expresses this as a decimal)
8.25	=	43,560 (square feet per acre) divided by 5,280 (feet per mile) = width of acre 1 mile long.

> **Example**: Ben and Bev typically bale alfalfa traveling four miles per hour. Their baler is only six feet wide but the swather width was 14 feet making the effective width of the baler 14 feet. The expected yield is four tons per acre. Table 5.2 indicates that balers are, on the average, 75% efficient. Given this information the tons/hour harvested will be

$$C_m = \frac{(4)(14)(4)\left(\frac{75}{100}\right)}{8.25} = 20.36 \ tons/hour \ .$$

Ranges and typical values for field speed and field efficiencies of machinery are given in Table 5.2. The data on field efficiency are almost always used in constructing cost estimates whereas the data on field speed provide a benchmark from which to compute individual estimates.

Repair and Maintenance

As discussed previously, total accumulated repair and maintenance costs can be estimated using the following ASAE formula due to Rotz and Bowers from equation 5.4 (here repeated as 5.8)

$$C_{rm\,t} = (RF1)(P_t)\left(\frac{h_t}{1,000}\right)^{RF2} \qquad \textbf{(5.8)}$$

where

$C_{rm\,t}$	=	total cumulative repair and maintenance cost at the end of year (hour) in dollars
P_t	=	machine initial list price in nominal dollars as of the end of the year (hour)
RF1	=	repair factor 1
RF2	=	repair factor 2

h_t = accumulated machine use in hours at the end of the t^{th} period.

For **repairs** and other costs estimated as a function of price, the **initial list price in nominal dollars at the end of the current period** is used. The initial list price is more stable than purchase price because of periodic dealer discounts and marketing incentives. It is assumed that the cumulative repair cost formula does not include any interest on the expense. For costs like **depreciation** (capital recovery), the expected **purchase price** after including typical discounts and incentives, rather than the list price, is used.

Example: Ben and Bev Dairyman own a 140-horsepower two-wheel (2WD) drive tractor and a 8-row (narrow) planter. These two machines will be used to illustrate estimating repair costs. For the purposes of this example we assume the tractor's initial list price is \$58,971. If there is no inflation, this would give a value in current nominal dollars of \$58,971. With inflation of 4.0% per year, the year-end value would be \$61,329.84. And we assume that Ben and Bev plan to use the tractor 300 hours per year and own the tractor for 20 years, a total of 6,000 hours of use. From Table 5.2, the repair cost factors are RF1 = .007 and RF2 = 2.0. The total repair costs over the period the tractor is owned are computed as follows:

$$C_{rm20}(tractor) = (.007)(58{,}971)\left(\frac{6{,}000}{1{,}000}\right)^{2.0} = \$14{,}860.69 \textit{ for the total over } 6{,}000 \textit{ hours}.$$

The total repair cost assuming 4% inflation for this year would be \$15,455.12. Figure 5.2 shows the total accumulated repairs for 2WD tractors with 500 hours of annual use as they are used. Repair cost is expressed as a percent of list price.

The planter has a list price of \$18,095 and will be used 75 hours per year for 15 years, a total of 1,125 hours. From Table 5.2, the repair factors are RF1 = .32 and RF2 = 2.1 so the cost is as follows:

$$C_{rm15}(planter) = (.32)(18{,}095)\left(\frac{1{,}125}{1{,}000}\right)^{2.1} = \$7{,}415.30 \textit{ for the total over } 1{,}125 \textit{ hours}.$$

Equation 5.8 gives total accumulated repair and maintenance costs for a machine that has been used h_t hours. The average cost per hour is calculated as

$$R/MCOST_h = \frac{C_{rm\,t}}{h_t} \tag{5.9}$$

where

$R/MCOST_h$	=	average repair and maintenance cost per hour
h_t	=	accumulated use of the machine in hours at the end of year t
C_{rmt}	=	total cumulative repair and maintenance cost in dollars.

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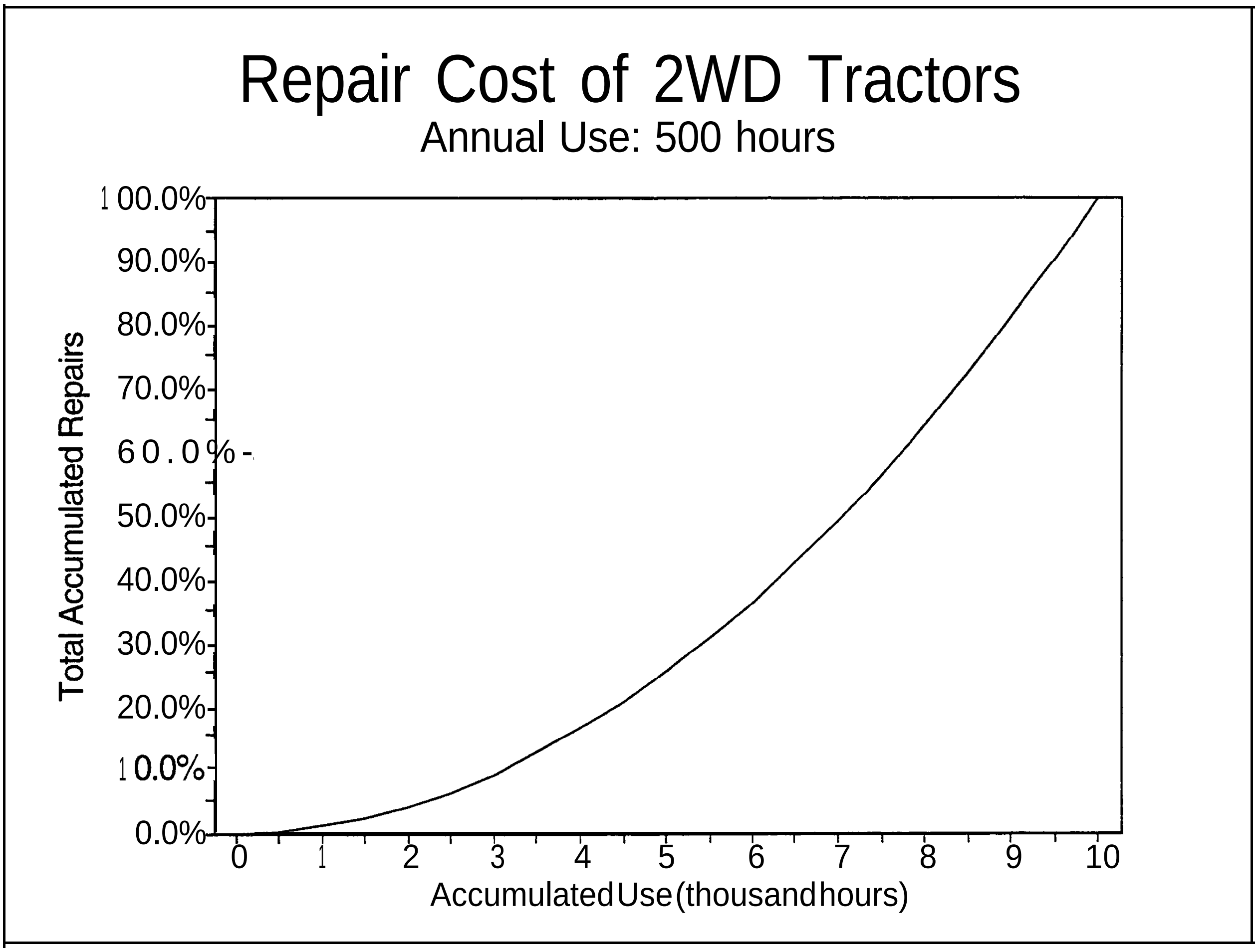
Figure 5.2. Total Accumulated Repairs as a Function of Hours of Use

Example: The total accumulated repair and maintenance cost of $14,860.69 for the tractor over the 6,000 hours the tractor is expected to be owned gives an expected hourly tractor repair charge of $2.4767. This gives an annual expense, assuming 300 hours of use, equal to $743.03. With inflation of 4.0% this is an annual cost of $772.75 and an hourly cost of $2.58. Using the same procedure, the $7,415.30 planter repair cost over 1,125 hours



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Time Adjustments for Repair Costs

Equation 5.8 can be used to estimate the total repair costs over the time of machine ownership. It is normally expected that as a machine ages, annual repair costs will rise. Although dividing the total lifetime repair costs by the number of hours of use gives the average repair per hour, it does not take into account the relative greater importance of current repair costs relative to costs later in machine life. As long as annual costs are more or less stable throughout the life of the machine, as with fuel and lubricants, converts to an hourly expected repair charge of $6.5914 and an annual charge of $494.35. With inflation of 4% in current year this is an hourly charge of $6.86.

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An alternative procedure to assuming uniform repairs over the life of the machine is to estimate the expected annual or hourly repair expenditure for each year of machine ownership using equation 5.8 recursively. Because of the uncertain nature of repair costs, this is not a recommended procedure for estimating expected costs for a particular year. However, for determining an average repair cost reflecting differential time flows, this recursive procedure is appropriate. Based on equation 5.8, equation 5.10 permits estimating the expected repair cost in any particular year (or hour). Cumulative repairs at the beginning of the t^{th} period in beginning-of-period dollars are given by $C_{rm\,t-1} = (RF1)(P_{t-1})\left(\frac{h_{t-1}}{1{,}000}\right)^{RF2}$. Repairs at the end of the period are given by $C_{rm\,t} = (RF1)(P_t)\left(\frac{h_t}{1{,}000}\right)^{RF2}$. The difference between these two is the nominal repair cost in the t^{th} year. But if a real repair cost is being estimated, the same price must be used for each term as follows:

$$
\begin{aligned}
RC_t &= (RF1)(P_t)\left(\frac{h_t}{1{,}000}\right)^{RF2} - (RF1)(P_t)\left(\frac{h_{t-1}}{1{,}000}\right)^{RF2} \\
&= (P_t)(RF1)\left[\left(\frac{h_t}{1{,}000}\right)^{RF2} - \left(\frac{h_{t-1}}{1{,}000}\right)^{RF2}\right]
\end{aligned}
\qquad \textbf{(5.10)}
$$

where

RC_t	=	repair costs for year t in dollars
P_t	=	machine list price in nominal dollars at the end of year t
RF1	=	repair factor 1
RF2	=	repair factor 2
h_{t-1}	=	accumulated machine use at beginning of year (or hour) t in hours
h_t	=	accumulated machine use at end of year (or hour) t in hours.

The second term in the first line of 5.10 is the cost in current dollars of the cumulative repairs as of the end of the previous period. It is based on the list price of the machine at the end of the current period but with usage as of the beginning of the period. When P_t is constant over time, equation 5.10 can be written (using 5.8) as follows:

$$\begin{aligned} RC_t &= (RF1)(P_t)\left(\frac{h_t}{1{,}000}\right)^{RF2} - (RF1)(P_t)\left(\frac{h_{t-1}}{1{,}000}\right)^{RF2} \\ &= C_{rm\,t} - C_{rm\,t-1}\,. \end{aligned} \qquad \textbf{(5.10a)}$$

Example: Consider the 140-horsepower 2WD tractor owned by Ben and Bev Dairyman. The tractor's initial list price is \$58,971. The repair and maintenance factors are RF1 = .007 and RF2 = 2.0. Previously the total repair cost for the 6,000 hours of useful life over 20 years were computed as \$14,860.69. The cumulative repair costs assuming constant prices for the machine over a 19-year life at 300 hours per year are computed as follows:

$$C_{rm15}(tractor) = (.007)(58{,}971)\left(\frac{5{,}700}{1{,}000}\right)^{2.0} = \$13{,}411.77 \textit{ for the total of } 5{,}700 \textit{ hours}.$$

The costs for the twentieth year are then given by the difference between \$14,860.69 and \$13,411.77, or \$1,448.92. Notice that because prices do not change we can simply subtract C_{rm19} from C_{rm20} to obtain the cost for year 20. If prices are changing, it is necessary to use the first line of equation 5.10 directly or multiply C_{rm19} by the inflation rate so that the same price can be factored out in equation 5.10. The costs for other years can be computed in a similar fashion, as in Table 5.3. One could also create a similar table with a row for each hour or month of machine use.

Table 5.3 Annualized Repair Cost for Example Tractor											
Tractor List price	58971										
Useful Life	20										
Annual Use	300										
Total Use	6000										
RF1	0.007										
RF2	2										
Real interest	0.05										
Annual Inflation (if applicable)	0.04										
Lifetime repairs (no inflation)	**14860.69**										
						Cummulated	Repair Cost	Cost in Year j	Cost in Year j	Annuity	
Year	Inflation rate	1+r	1 + p	Hours	Hours	Cost	During	Disc. to	Disc. to	with Value	Discounted
	(actual)			Beg	End	at End of Year j	year j	Beg Year 1	End Year 1	of PV0	Annuity
1	0.000	1.050	1.000	0	300	37.151730	37.152	35.3826	37.151730	624.369383	594.637508
2	0.000	1.050	1.000	300	600	148.606920	111.455	101.0931429	106.147800	624.369383	566.321436
3	0.000	1.050	1.000	600	900	334.365570	185.759	160.4653061	168.488571	624.369383	539.353748
4	0.000	1.050	1.000	900	1200	594.427680	260.062	213.9537415	224.651429	624.369383	513.670237
5	0.000	1.050	1.000	1200	1500	928.793250	334.366	261.9841733	275.083382	624.369383	489.209749
6	0.000	1.050	1.000	1500	1800	1337.462280	408.669	304.9551223	320.202878	624.369383	465.914047
7	0.000	1.050	1.000	1800	2100	1820.434770	482.972	343.2395316	360.401508	624.369383	443.727664
8	0.000	1.050	1.000	2100	2400	2377.710720	557.276	377.1862985	396.045613	624.369383	422.597775
9	0.000	1.050	1.000	2400	2700	3009.290130	631.579	407.121719	427.477805	624.369383	402.474071
10	0.000	1.050	1.000	2700	3000	3715.173000	705.883	433.3508493	455.018392	624.369383	383.308639
11	0.000	1.050	1.000	3000	3300	4495.359330	780.186	456.1587888	478.966728	624.369383	365.055847
12	0.000	1.050	1.000	3300	3600	5349.849120	854.490	475.8118885	499.602483	624.369383	347.672235
13	0.000	1.050	1.000	3600	3900	6278.642370	928.793	492.5588908	517.186835	624.369383	331.116414
14	0.000	1.050	1.000	3900	4200	7281.739080	1003.097	506.632002	531.963602	624.369383	315.348966
15	0.000	1.050	1.000	4200	4500	8359.139250	1077.400	518.2479033	544.160298	624.369383	300.332349
16	0.000	1.050	1.000	4500	4800	9510.842880	1151.704	527.6087028	553.989138	624.369383	286.030808
17	0.000	1.050	1.000	4800	5100	10736.849970	1226.007	534.9028324	561.647974	624.369383	272.410294
18	0.000	1.050	1.000	5100	5400	12037.160520	1300.311	540.3058913	567.321186	624.369383	259.438375
19	0.000	1.050	1.000	5400	5700	13411.774530	1374.614	543.9814415	571.180514	624.369383	247.084167
20	0.000	1.050	1.000	5700	6000	14860.692000	1448.917	546.081756	573.385844	624.369383	235.318254
Sum							**14860.692**				
Present Value at Beginning of 1								**7781.022582**			**7781.02258**
Present Value at End of 1									8170.073711		
US0(r,20)								12.46221034			
Real Annuity with Value PV 0								**624.369383**			
Real Annuity with Value PV 1									655.5878521		

Because prices are assumed to be constant, the cost per year is just the difference in the cumulative costs. For example, the cost in year 4 is 594.43 - 334.37 = $260.06. As suggested in Chapter 2, these varying annual costs can be converted to a constant real annuity using capital budgeting procedures. The present value of this cost stream at the beginning of the first year is $7,781.02. The amortized average annual repair cost with this same present value can be determined using equation 5.11 (assuming a zero inflation rate).

$$ARC = \frac{\left(\sum_{j=1}^{n} \frac{RC_j}{(1+r)^j} \right)}{US_0(r,n)} = \frac{\left(\sum_{j=1}^{n} \frac{RC_j}{(1+r)^j} \right)}{\left(\frac{1 - \frac{1}{(1+r)^n}}{r} \right)} = \frac{r}{1-(1+r)^{-n}} \cdot \sum_{j=1}^{n} \frac{RC_j}{(1+r)^j} \qquad \textbf{(5.11)}$$

where

ARC	=	amortized average annual repair cost
r	=	real interest rate
n	=	years of life
RC_j	=	repair costs for year j as estimated using equation 5.10
$US_0(r,n)$	=	uniform series having interest rate r and n periods.

This annuity can also be obtained using the standard annuity functions available on business calculators or in spreadsheet programs (such as PMT in EXCEL). Those using calculators and spreadsheet functions to determine the present value of a series should be sure the calculations are performed assuming payments are made at the end of each period. For the example tractor these computations are presented explicitly in Table 5.3. For this example the annual repair amount is $624.37 as compared to $743.03 ($772.75 with inflation) using equation 5.8 directly and dividing the cost by total years of use. This is a payment at the end of each year that has the same present value as the various RC_t. This annual annuity amount can then be divided by the number of hours of use per year to estimate a repair and maintenance cost per hour. Because the annuity represents a payment at the end of year and repairs occur at various times during the year, these hourly expenses should be charged interest at a real rate from the time of occurrence to the end of the year. Using the real rate is appropriate because prices are assumed not to change during the year. Walker and Kletke indicate that for a cotton budget in southwest Oklahoma, changing the repair computation procedure from equations 5.8 and 5.9 to equations 5.11 and 5.9 for all machines can decrease the cost per acre from $19.53 to $17.98 per acre. As discussed in Appendix 2C, this annuity could be combined with the annuity constructed to represent the other costs of owning and using machinery to estimate an annual user cost of the capital asset (Burt 1992).

A concern with repair cost estimation is whether the repair cost equations generate costs in real or nominal terms. The preceding example assumes no inflation so that nominal and real values and interest rates are the same. If it is likely that the repair cost coefficients were estimated using survey data and were not adjusted, then the costs are likely in nominal terms. If the cost coefficients were determined by an "expert" using personal knowledge and information about the number of moving parts, and so forth, then the costs are likely in real terms. Although it is uncertain whether the repair costs are in real or nominal terms, it is usually assumed that they are in real terms at the point of estimation. This means that they are assumed to be in both real and nominal terms as of the end of the current year (period). If the list price is in nominal terms at the beginning of the production period, it should be adjusted to the end of the year using the current inflation rate before proceeding with repair cost estimation. Each of the costs in subsequent years can then be adjusted to the beginning of the first period to obtain a present value of total accumulated repair and maintenance costs. This present value can then be converted to an annuity for use in projecting average annual costs. The convention is to compute a real annuity having the same present value as the actual repair stream (real or nominal) and then adjust it using the appropriate inflation rate to obtain a nominal (or real) cost for each year.

It is usually assumed that repair costs occur and are paid when the machine is used. These costs will accumulate operating interest on repair and maintenance costs from the time the operation takes place until the end of the estimation period. The computed real annuity after inflation adjustments (or annual repair cost using equation 5.8) is in nominal terms at the end of the first period (year). Expenditures for repairs prior to the end of the period will accrue interest at a nominal rate from the point of occurrence to the termination point. But because inflation is assumed to occur during the production period, the actual expenditure at the earlier point has a lesser nominal value. Specifically, if a_e is a nominal payment at the end of the period, then the value at an expenditure point k months earlier is $a_{e-k} = a_e(1+p)^{\frac{-k}{12}}$ where p is the annual inflation rate. If this expenditure accrues interest at a nominal rate (i) the total cost including interest is given by

$$a_{e-k}\,(1+i)^{\frac{k}{12}} = a_e(1+p)^{\frac{-k}{12}}\,(1+i)^{\frac{k}{12}}\,.$$

To compute the interest component we subtract the expenditure without interest and then simplify,

$$\begin{aligned} ic(repairs) &= \left[a_e(1+p)^{\frac{-k}{12}}\right](1+i)^{\frac{k}{12}} - \left[a_e\;(1+p)^{\frac{-k}{12}}\right] \\ &= a_e(1+p)^{\frac{-k}{12}}\,(1+r)^{\frac{k}{12}}\,(1+p)^{\frac{k}{12}} - \left[a_e\;(1+p)^{\frac{-k}{12}}\right] \\ &= a_e\left((1+r)^{\frac{k}{12}} - (1+p)^{\frac{-k}{12}}\right) \\ &= a_e\;(1+p)^{\frac{-k}{12}}\left((1+i)^{\frac{k}{12}} - 1\right) \end{aligned} \qquad \textbf{(5.12)}$$

where ic(repairs) is the interest charge. This is the nominal interest on the nominal expenditure ($a_e\;(1+p)^{\frac{-k}{12}}$) for k months as given by equation 2.15.

Total repairs for a year in nominal dollars are usually allocated over the year by hours using total hours of use per year as in equation 5.9. This gives a cost per hour of use in end-of-year dollars. If hours of use per month are equal, this annual total cost can be divided into a nominal cost per month by finding a constant real cost per month that translates into total nominal expenditure. If real and nominal prices and costs are equal as of December 31 then a constant real cost, a_r, can be found using equation 5.13,

$$a_r(1+p)^{-\frac{11}{12}} + a_r(1+p)^{-\frac{10}{12}} + \ldots + a_r(1+p)^{-\frac{0}{12}} = a_r \sum_{j=1}^{12} (1+p)^{\frac{(j-12)}{12}} = Nom\ Exp \tag{5.13}$$

where the sum of nominal costs adds up to nominal expenditures (Nom Exp). Standard annuity functions and equation 5.14 can be used to find a_r,

$$\begin{aligned} a_r &= \frac{Nom\ Exp}{\sum_{j=1}^{12} (1+p)^{\frac{(j-12)}{12}}} = \frac{Nom\ Exp}{\sum_{j=1}^{12} (1+p_m)^{(j-12)}} \\ &= \frac{Nom\ Exp}{(1+p_m)\sum_{j=1}^{12} (1+p_m)^{(j-12-1)}} \\ &= \frac{1}{(1+p_m)}\left[\frac{Nom\ Exp}{US_0(p_m, 12)}\right] \end{aligned} \tag{5.14}$$

where p_m is the monthly inflation rate computed from equation 2.12. The last expression is obtained using equation 2B.7 and is the annuity having a present value of Nom Exp multiplied by $\left(\frac{1}{(1+p_m)}\right)$. This expression is thus easy to compute using standard functions such as PMT in Excel. By multiplying a_r by the appropriate monthly discount factor, a nominal cost per month for repairs is found. In such a nominal analysis with prices rising at the rate of inflation during the year, an hour of machine time will cost less at the beginning of the year than at the end. The nominal cost at the end of the year is the sum of the costs each hour or month.

If, as is probably more common, the number of hours per month varies over the year, a more complicated procedure is needed. In such a situation it is appropriate to find a constant real price per hour which, when adjusted for inflation and then multiplied by the number of hours per month and summed, is equal to total nominal expenditures. If the base period is the end of the twelfth month (December), we seek a constant real repair cost per hour R/M_h such that the following identity holds:

$$\sum_{j=1}^{12} R/M_h (1+p)^{\frac{j-12}{12}} h_j = Nom\ Exp \qquad \textbf{(5.15)}$$

where it is assumed that R/M_h is the real and nominal cost per hour at the end of December and h_j is hours of use in the j^{th} month (1=January and so forth). This equation can be solved for R/M_h as in equation 5.14 as follows:

$$\begin{aligned} R/M_h &= \frac{Nom\ Exp}{\sum_{j=1}^{12} h_j (1+p)^{\frac{(j-12)}{12}}} \\ &= \frac{Nom\ Exp}{\sum_{j=1}^{12} h_j (1+p_m)^{(j-12)}} . \end{aligned} \qquad \textbf{(5.16)}$$

Unlike equation 5.14, this cannot be simplified using standard annuity formulas due to the presence of h_j in the summation. This real value can then be adjusted for inflation to give a nominal cost per hour for each month. This nominal cost per hour is given by

$$R/M_h^n(j) = R/M_h (1+p_m)^{(j-12)} \qquad \textbf{(5.17)}$$

where the superscript n denotes the nominal cost and j denotes the j^{th} month.

Given the complexity of equations 5.14 and 5.16, an alternative is to assume constant nominal expenditures over the course of the year and use the average nominal cost per hour in year-end dollars as the cost for all hours during the year. This nominal cost per hour at the end of the year is also the real cost per hour since real and nominal values are equal at the end of the period. These "average" expenditures will, of course, sum to the total, but will overstate costs in the first part of the year.

Example: Consider the example tractor with an assumed list price $58,971 and an annual inflation rate during the first year of 4.0%. This gives a year-end nominal list price of $61,329.84. The total accumulated repair and maintenance cost of $15,455.12 for the tractor over the 6,000 hours the tractor is expected to be owned gives an expected hourly tractor repair charge of $2.5785 which is reported in the cost per hour column in the exhibit below on the line labeled Nominal repair cost (equal use per month). This gives an annual expense, assuming 300 hours of use, equal to $772.756. The operating interest on this can be calculated in a variety of different ways. Exhibit 5.1 below shows the computations for three alternative methods.

Exhibit 5.1 Alternative Methods to Calculate Interest on Repair Expenses

List price of tractor	58971
Useful life of tractor	20
Annual use	300
Total use	6000
RF1	0.007
RF2	2
Real interest rate	0.05
Inflation rate	0.04
Nominal interest rate	0.092
Monthly inflation rate	0.003274
Total repair expense over tractor's life (inflation = 4%)	15455.12
Cost/hour for repairs	**2.575853**
Cost/year for repairs	**772.756**
US0 (monthly inflation, 12)	11.7485

Item	Cost Per Hour	1 Jan	2 Feb	3 Mar	4 Apr	5 May	6 Jun	7 July	8 Aug	9 Sep	10 Oct	11 Nov	12 Dec	Per Month	Per Year
Hours of use per month		15.00	20.00	20.00	30.00	45.00	30.00	25.00	25.00	30.00	30.00	20.00	10.00	25.000	300.000
Real repair cost (equal use per month)	*2.62241*	65.56	65.56	65.56	65.56	65.56	65.56	65.56	65.56	65.56	65.56	65.56	65.56	65.560	
Nominal repair cost (equal use per month)	**2.57585**	63.25	63.45	63.66	63.87	64.08	64.29	64.50	64.71	64.92	65.13	65.35	65.56	64.396	**772.756**
Interest on line above		5.31	4.83	4.34	3.86	3.38	2.89	2.41	1.93	1.44	0.96	0.48	0.00		31.837
Nominal repair cost (average cost/hour & actual use)	**2.57585**	38.64	51.52	51.52	77.28	115.91	77.28	64.40	64.40	77.28	77.28	51.52	25.76	64.396	**772.756**
Interest on line above		3.25	3.92	3.52	4.67	6.11	3.48	2.41	1.92	1.72	1.14	0.38	0.00		32.497

The first line gives the actual hours of use each month. If this information were not available and it was instead assumed that hours of use per month were equal, equation 5.14 could be used to obtain a constant real payment that when converted to nominal terms would sum to the annual total expense of \$772.756. The computations are as follows:

$$a_r = \frac{1}{(1+p_m)}\left[\frac{Nom\ Exp}{US_0(p_m, 12)}\right] = \frac{1}{1.003274}\,\frac{772.756}{11.7485} = 65.5602\,.$$

This real payment appears in the per month column (and also the other columns) on the Real repair cost (equal use per month) line of Exhibit 5.1. The cost per hour in the real repair cost line is given by dividing the cost per month by the hours per month (\$65.5602/25) to obtain \$2.6224. This amount can then be adjusted to a nominal basis using the monthly adjustment formula analogous to equation 5.17. For example, the nominal cost in the eighth month [R/M^n (8)] is given by

$$R/M^n(8) = a^r(1+p_m)^{(8-12)} = (65.5602)\ (1.003274)^{-4} = 64.708\,.$$

The sum of these costs is \$772.756. Note that the cost per hour in effect rises over the year so that the cost of 25 hours in January is less than in December. Nominal interest on these expenses is \$31.837.

Rather than assuming that repairs are evenly spaced over the year, we can use the nominal cost per hour and multiply it by the hours of use each month. This will give the correct total repairs but will not allocate them in a way that accounts for rising prices during the year. To obtain the cost in the eighth month, take the number of hours in the eighth month (25) and multiply by the average cost per hour (\$2.5758) to obtain \$64.395. In this case, the costs in June and September are the same since the hours are the same. Nominal interest in this case is \$32.497.

The final and correct method is to construct a nominal cost per hour that is different for each month, accounts for different use per month, and sums to total nominal cost. This is done using equations 5.16 and 5.17. The denominator of equation 5.16 is constructed in the line of Exhibit 5.1 labeled Inflation-adjusted hours. The sum of this row is the denominator of 5.16. The real cost per hour is then given by

$$R/M_h = \frac{772.756}{294.589} = 2.62316\,.$$

This is reported in the cost/hour column and the real repair cost (actual use) line. The nominal cost per hour can be calculated for each month using 5.17. For the eighth month we obtain

$$\left[R/M_h^n\ (8)\right] h_8 = R/M_h(1 + p_m)^{(8-12)}\, h_8 = (2.62316)(1.003274)^{-4}(25) = 64.727\,.$$

The sum of these expenditures is also \$772.756. This set of monthly expenditures allows for differential hours and prices (due to inflation) each month. The interest on these expenditures is \$32.322. This is less than the interest expense computed using the average nominal cost per hour for every month and will always be so if inflation is positive.

Given the fact that interest on repair expenditures is usually a small proportion of total costs, the error created by charging interest on the average rather than the correct nominal value is probably not significant. In situations where computations are completely automated using a computer program, the cost of using the correct procedure is not great and could be used.

If it is assumed that all repair costs are estimated in nominal dollars, then equation 5.18 can be used to estimate a real amortized average annual repair cost. The primary difference is that each repair cost must be additionally deflated by the inflation rate to convert it to real dollars.

$$ARC = \frac{r}{1-(1+r)^{-n}} \cdot \sum_{j=1}^{n} \frac{RC_j}{(1+p_j)^j (1+r)^j} \qquad \textbf{(5.18)}$$

where

ARC	=	amortized average annual repair cost
p_j	=	inflation rate
r	=	real interest rate
n	=	years of life
RC_j	=	repair costs for year j as estimated using equation 5.10 assuming all costs are in nominal dollars.

Equation 5.18 is a general form of 5.11 and will yield the same answer when inflation is zero in every period. If we assume that inflation occurs each year at a 4.0% rate, then nominal machine repair cost will increase over time as in Table 5.4. The cost during year t is computed by subtracting from the accumulated cost at the end of year t $[RC_t]$, the inflation-adjusted cost at the end of year t-1 $[(1+p)RC_{t-1}]$. This is made precise in equation 5.10b where p_t is the inflation rate in period t.

$$\begin{aligned} RC_t &= (RF1)(P_t)\left(\frac{h_t}{1{,}000}\right)^{RF2} - (RF1)(P_t)\left(\frac{h_{t-1}}{1{,}000}\right)^{RF2} \\ &= (RF1)(P_t)\left(\frac{h_t}{1{,}000}\right)^{RF2} - (RF1)(1+p_t)(P_{t-1})\left(\frac{h_{t-1}}{1{,}000}\right)^{RF2} \qquad \textbf{(5.10b)} \\ &= C_{rm\,t} - (1+p_t)C_{rm\,t-1}. \end{aligned}$$

Table 5.4 Annualized Repair Cost for Example Tractor with 4% Inflation Each Year											
Tractor List price	58971										
Useful Life	20										
Annual Use	300										
Total Use	6000										
RF1	0.007										
RF2	2										
Real interest	0.05										
Annual Inflation (if applicable)	0.04										
Lifetime repairs (no inflation)	**14860.69**										
						Cummulated	Repair Cost	Cost in Year j	Cost in Year j	Annuity	
Year	Inflation rate	1+r	$1+\rho$	Hours	Hours	Cost	During	Disc. to	Disc. to	with Value	Discounted
	(actual)			Beg	End	at End of Year j	year j	Beg Year 1	End Year 1	of PV0	Annuity
1	0.040	1.050	1.040	0	300	38.63779920	38.63780	35.3826	38.6377992	649.34416	594.63751
2	0.040	1.050	1.040	300	600	160.73324467	120.54993	101.0931429	110.393712	675.31792	566.32144
3	0.040	1.050	1.040	600	900	376.11579253	208.95322	160.4653061	175.2281143	702.33064	539.35375
4	0.040	1.050	1.040	900	1200	695.39630975	304.23589	213.9537415	233.6374857	730.42387	513.67024
5	0.040	1.050	1.040	1200	1500	1130.01900334	406.80684	261.9841733	286.0867172	759.64082	489.20975
6	0.040	1.050	1.040	1500	1800	1692.31645941	517.09670	304.9551223	333.0109936	790.02645	465.91405
7	0.040	1.050	1.040	1800	2100	2395.56796587	635.55885	343.2395316	374.8175685	821.62751	443.72766
8	0.040	1.050	1.040	2100	2400	3254.06130221	762.67062	377.1862985	411.8874379	854.49261	422.59777
9	0.040	1.050	1.040	2400	2700	4283.15818903	898.93443	407.121719	444.5769171	888.67232	402.47407
10	0.040	1.050	1.040	2700	3000	5499.36360073	1044.87908	433.3508493	473.2191275	924.21921	383.30864
11	0.040	1.050	1.040	3000	3300	6920.39915516	1201.06101	456.1587888	498.1253973	961.18798	365.05585
12	0.040	1.050	1.040	3300	3600	8565.28080560	1368.06568	475.8118885	519.5865823	999.6355	347.67224
13	0.040	1.050	1.040	3600	3900	10454.40107216	1546.50903	492.5588908	537.8743088	1039.6209	331.11641
14	0.040	1.050	1.040	3900	4200	12609.61606242	1737.03895	506.632002	553.2421462	1081.2058	315.34897
15	0.040	1.050	1.040	4200	4500	15054.33754392	1940.33684	518.2479033	565.9267104	1124.454	300.33235
16	0.040	1.050	1.040	4500	4800	17813.63034530	2157.11930	527.6087028	576.1487035	1169.4321	286.03081
17	0.040	1.050	1.040	4800	5100	20914.31537728	2388.13982	534.9028324	584.1138929	1216.2094	272.41029
18	0.040	1.050	1.040	5100	5400	24385.07857968	2634.19059	540.3058913	590.0140333	1264.8578	259.43837
19	0.040	1.050	1.040	5400	5700	28256.58611714	2896.10439	543.9814415	594.0277342	1315.4521	247.08417
20	0.040	1.050	1.040	5700	6000	32561.60616269	3174.75660	546.081756	596.3212775	1368.0702	235.31825
Sum							**25981.646**				
Present Value Beginning of 1								**7781.022582**			**7781.0226**
Present Value End of 1									8496.876659		
US0(r,20)								12.46221034			
Real Annuity PV 0								**624.369383**			
Real Annuity PV 1									681.8113662		

Equation 5.10b is equivalent to equations 5.10a and 5.10 when the inflation rate is zero. The cost in year 4 in Table 5.4 is obtained as 695.3963 - (1.04)(376.1158) = $304.2359. The present value of this entire income stream is $7,781.023, as before. The inflation-adjusted annuity value of $649.34 would be used as the cost for the first year. This could then be divided by the hours of use per year to get a cost per hour. This would then be charged interest at the nominal rate for the year from the time the hour of machine time was consumed until the end of the period.

If, as suggested in Chapter 2 and discussed in more detail in Chapters 6 and 10, nominal interest rates (including inflation) are assumed for the current year but real rates are used for periods other than the current one, equation 5.18 can be adjusted to reflect no inflation in list prices past the first year and then use real interest rates for future periods. If inflation occurs at a 4.0% rate during the production year but it is assumed there is no inflation thereafter, the results in Table 5.5 are obtained. As before, the present value of the cost stream is $7,781.023 with a real annuity value of $624.369. It is increased in the first year by 4.0% to $649.344 and remains the same thereafter. This can then be divided by annual hours of use to obtain a cost per hour. Interest on repair costs during the year occur at a real rate of interest.

The Task Force recommends that repair costs be estimated using either equations 5.8 and 5.9, which do not adjust for repair costs changing over time, or equations 5.18 and 5.9, which create a constant real annuity that reflects changing costs over time. If the latter set of equations (based on capital budgeting) are used to estimate repair costs, it is important these equations also be used for depreciation, taxes, and other costs that may vary substantially through time.

Repair Cost Estimates for Used Machines

It is expected that as machines age, repairs per hour will increase. This is also one of the characteristics of the repair cost equations. Thus repairs for a portion of machine life beginning at some point after the machine is new can be estimated by first determining repairs for the number of hours of use before acquisition and subtracting the results from the expected repairs for total machine life at the time it is retired by the second owner. Repair costs vary widely and the results are good only for use as expected repairs. As machines age, overhauls will be required and whether that occurs before or after a used machine is purchased can affect repair costs significantly.

Example: One of the tractors on the Midwest Dairy Farm was purchased used. A 1982 140-horsepower tractor was purchased in 1987 and had been used for 2,750 hours as of the beginning of 1992. The real list price of this tractor as of the end of 1991 is estimated to be $58,971 based on the list price of a similar new tractor in 1991. The Dairymans expect to use the tractor for 10 additional years for about 300 hours each year. When Ben and Bev sell the tractor, it will have a total of 5,750 hours (2,750 + (10)(300)) of use. We compute the cumulative cost of repairs over the first 10 years of use and then the cost of repairs over the second 10 years of use. This will give a higher cost per hour for the second ten years given the rising pattern of repair costs.

Table 5.5 Annualized Repair Cost for Example Tractor with 4% Inflation in Production Year and None Thereafter											
Tractor List price	58971										
Useful Life	20										
Annual Use	300										
Total Use	6000										
RF1	0.007										
RF2	2										
Real interest	0.05										
Annual Inflation (if applicable)	0.04										
Lifetime repairs (no inflation)	**14860.69**										
						Cummulated	Repair Cost	Cost in Year j	Cost in Year j	Annuity	
Year	Inflation rate	1+r	1+p	Hours	Hours	Cost	During	Disc. to	Disc. to	with Value	Discounted
	(actual)			Beg	End	at End of Year j	year j	Beg Year 1	End Year 1	of PV0	Annuity
1	0.040	1.050	1.040	0	300	38.63779920	38.63780	35.3826	38.6377992	649.34416	594.63751
2	0.000	1.050	1.000	300	600	154.55119680	115.91340	101.0931429	110.393712	649.34416	566.32144
3	0.000	1.050	1.000	600	900	347.74019280	193.18900	160.4653061	175.2281143	649.34416	539.35375
4	0.000	1.050	1.000	900	1200	618.20478720	270.46459	213.9537415	233.6374857	649.34416	513.67024
5	0.000	1.050	1.000	1200	1500	965.94498000	347.74019	261.9841733	286.0867172	649.34416	489.20975
6	0.000	1.050	1.000	1500	1800	1390.96077120	425.01579	304.9551223	333.0109936	649.34416	465.91405
7	0.000	1.050	1.000	1800	2100	1893.25216080	502.29139	343.2395316	374.8175685	649.34416	443.72766
8	0.000	1.050	1.000	2100	2400	2472.81914880	579.56699	377.1862985	411.8874379	649.34416	422.59777
9	0.000	1.050	1.000	2400	2700	3129.66173520	656.84259	407.121719	444.5769171	649.34416	402.47407
10	0.000	1.050	1.000	2700	3000	3863.77992000	734.11818	433.3508493	473.2191275	649.34416	383.30864
11	0.000	1.050	1.000	3000	3300	4675.17370320	811.39378	456.1587888	498.1253973	649.34416	365.05585
12	0.000	1.050	1.000	3300	3600	5563.84308480	888.66938	475.8118885	519.5865823	649.34416	347.67224
13	0.000	1.050	1.000	3600	3900	6529.78806480	965.94498	492.5588908	537.8743088	649.34416	331.11641
14	0.000	1.050	1.000	3900	4200	7573.00864320	1043.22058	506.632002	553.2421462	649.34416	315.34897
15	0.000	1.050	1.000	4200	4500	8693.50482000	1120.49618	518.2479033	565.9267104	649.34416	300.33235
16	0.000	1.050	1.000	4500	4800	9891.27659520	1197.77178	527.6087028	576.1487035	649.34416	286.03081
17	0.000	1.050	1.000	4800	5100	11166.32396880	1275.04737	534.9028324	584.1138929	649.34416	272.41029
18	0.000	1.050	1.000	5100	5400	12518.64694080	1352.32297	540.3058913	590.0140333	649.34416	259.43837
19	0.000	1.050	1.000	5400	5700	13948.24551120	1429.59857	543.9814415	594.0277342	649.34416	247.08417
20	0.000	1.050	1.000	5700	6000	15455.11968000	1506.87417	546.081756	596.3212775	649.34416	235.31825
Sum							**15455.11968**				
Present Value Beginning of 1								**7781.022582**			**7781.0226**
Present Value End of 1									8496.876659		
US0(r,20)								12.46221034			
Real Annuity PV 0								**624.369383**			
Real Annuity PV 1									681.8113662		

$$C_{rm10}(2{,}750\ \ hours) = (.007)(58{,}971)\left(\frac{2{,}750}{1{,}000}\right)^{2.0} = \$3{,}121.78$$
$$C_{rm20}(5{,}750\ \ hours) = (.007)(58{,}971)\left(\frac{5{,}750}{1{,}000}\right)^{2.0} = \$13{,}648.10\,.$$

The total repairs for hours 2,751 through 5,750 = \$13,648.10 - \$3,121.78 = \$10,526.32. This gives a cost per hour for the remainder of the life of the machine of \$3.51 (10,526.32/3,000). If there was 45 inflation during the current year, this would be revised to \$14,194.02 - \$3,246.65 = \$10,947.37 or \$3.649 per hour.

Fuel and Lubricants

Fuel and lube costs also can be estimated by survey or engineering equations. Survey procedures appropriate for general machinery operating costs also can be appropriate for fuel and lubricants. ASAE equations can be used to estimate the fuel efficiency or fuel consumption of the power unit. The fuel consumption is then multiplied by the fuel cost per unit to estimate fuel cost. Oil consumption can be estimated using engineering equations as well.

Engineering Equation Fuel Cost Estimates

The ASAE Standards give two methods for estimating fuel consumption. An average method can be used when an estimate of annual average fuel consumption for power units is all that is needed. This method is useful for predicting overall machinery costs for a given enterprise. When determining the costs for a specific operation (planting), fuel requirements should be based on the detailed formulas.

Average annual fuel consumption for a given power unit can be estimated as follows:

$$\begin{aligned} Gas_{gph} &= (.06)\ (PTO_{\max}) \\ Diesel_{gph} &= (.06)\ (PTO_{\max})\ (.73) \\ LPG_{gph} &= (.06)\ (PTO_{\max})\ (1.2) \end{aligned} \qquad \textbf{(5.19)}$$

where

Gas_{gph}	=	average gasoline consumption, gallons per hour
$Diesel_{gph}$	=	average diesel consumption, gallons per hour
LPG_{gph}	=	average liquefied petroleum consumption, gallons per hour
PTO_{max}	=	maximum PTO horsepower per hour.

The detailed method for estimating fuel consumption per hour is calculated as

$$F_{gph} = (HPR)\ (FM_{fuel}) \qquad \textbf{(5.20)}$$

where

F_{gph}	=	fuel consumption in gallons per hour
HPR	=	equivalent PTO horsepower required
FM_{fuel}	=	fuel use multiplier for fuel type as defined below.

The fuel multipliers (FM) are given in equation 5.21.

$$\begin{aligned} FM_{gas} &= (.54)\ (\frac{HPR}{HPM}) + (.62) - (.04)\ \sqrt{(697)\ (\frac{HPR}{HPM})} \\ FM_{diesel} &= (.52)\ (\frac{HPR}{HPM}) + (.77) - (.04)\ \sqrt{(738)\ (\frac{HPR}{HPM}) + 173} \\ FM_{lpg} &= (.53)\ (\frac{HPR}{HPM}) + (.62) - (.04)\ \sqrt{(646)\ \frac{HPR}{HPM}} \end{aligned} \qquad \textbf{(5.21)}$$

where

FM_{gas}	=	fuel multiplier for gas engines, gallons per horsepower per hour
FM_{diesel}	=	fuel multiplier for diesel engines, gallons per horsepower per hour
FM_{lpg}	=	fuel multiplier for lpg engines, gallons per horsepower per hour
HPR	=	equivalent PTO horsepower required
HPM	=	maximum PTO horsepower.

Example: The more detailed way to estimate fuel consumption is with equations 5.20 and 5.21. The additional information required is the equivalent HPR required to pull the load for the implement in question. For this illustration it is assumed that the planter requires using 70 of the 140 horsepower available.

$$F_{gph}(140\ hp\ \ tractor) = (70)\ FM_{diesel}\ \text{ where}$$

$$FM_{diesel} = (.52)\ (\frac{70}{140}) + (.77) - (.04)\ \sqrt{(738)\ (\frac{70}{140}) + 173} = .09876, \text{ so}$$

$$F_{gph}(140\ hp\ \ tractor) = (70)\ (0.09876) = 6.91\ \ gallons/hour\,.$$

Engineering Equation Lube Cost Estimates

A general estimate of oil consumption given by the ASAE Standards is .01 to .025 gallons per hour, depending on the volume of the engine crankcase. A detailed method relating oil consumption to engine size is given by the ASAE Standards as

$$\begin{aligned} Oil_{gas} &= (.00011)\ (HP) + (.00657) \\ Oil_{diesel} &= (.00021)\ (HP) + (.00573) \\ Oil_{lpg} &= (.00008)\ (HP) + (.00755) \end{aligned} \qquad \textbf{(5.22)}$$

where

Oil_{gas}	=	oil consumption for gas engines, gallons per hour
Oil_{diesel}	=	oil consumption for diesel engines, gallons per hour
Oil_{lpg}	=	oil consumption for lpg engines, gallons per hour
HP	=	rated engine horsepower.

Example: The estimated lube cost for the tractor is

$$Oil_{diesel}(140\ hp\ tractor) = (.00021)(140) + .00573 = .0351\ gallons/hour\ .$$

If filters are changed every other oil change, the total lube cost per hour approaches 15% of the total fuel cost.

Suggestions for Estimating Costs for Machines Not Listed in Tables

It is impossible for Table 5.2 to include all machines. When costs must be estimated for a machine not listed, and cost estimates are not otherwise available, it is suggested that parameters for a similar machine be used. Look through the tables for a machine having a similar number of moving parts, a similar power source, and a similar type of use. When estimating repairs, the key parameter in Table 5.2 is the ASAE total life repair cost. This coefficient determines the dollar amount of repairs over machine life. The other parameters only determine the distribution of those costs over machine life. For any machine, the equations provide an estimate of expected average repair costs over a number of hours of use and it is not likely that using coefficients for a similar machine will greatly over- or underestimate expected repair costs.

IRRIGATION OPERATING COSTS

There is not a consensus for how to estimate repair costs for irrigation equipment. The ASAE does not publish equations for estimating repair costs of irrigation equipment in the ASAE Standards, and extensive surveys have not been undertaken to estimate these costs.

One of the key elements in determining irrigation costs is application efficiency. For example, if the intent is to apply 12 inches of water using a surface system and if the application efficiency of flood application is 60%, it will be necessary to pump 20 inches of water to obtain the desired 12 inches. The application efficiency depends on the type of irrigation system, the type of soil, and weather conditions such as wind velocity and humidity.

Repair and Maintenance Cost Estimates

Jensen [1980] gives guidelines on estimating annual maintenance and repairs as a percent of initial cost. McGrann et al. [1986a, 1986b] use these same procedures. Table 5.6 gives these estimates for typical irrigation equipment. Thompson and Fischbach and later Selley use a different approach to estimating repair and maintenance costs for irrigation equipment. Table 5.7 gives the estimated repair and maintenance cost for power units and Table 5.8 presents delivery system repair and maintenance. As an example consider the following system.

Example Irrigation System

System Component	Initial Cost
Well (250 feet)	$11,850
Column Pipe (200 feet)	$8,016
Electric Switches	$1,701
Electric Service	$4,976
Land Shaping	$4,000
Pump Base	$1,433
Pump	$3,335
Electric Motor	$3,190
Sprinkler System	$30,000
Total	$68,501

Repair estimates using the McGrann et al. procedure are determined by applying coefficients from Table 5.6 to the expected investment given above. The McGrann et al. procedure provides annual estimates that do not depend on use. In this illustration the average of the upper and lower percent range in costs is used.

Repair Costs - McGrann et al. Procedure

Item	Percent	Annual Cost
Well	1	$118.50
Column Pipe	4	$320.64
Electric Switches	2	$34.02
Electric Service	0	0.00
Land Shaping	0	0.00
Pump Base	1	$14.33
Pump	6	$200.10
Electric Motor	2	$63.80
Sprinkler System	6.5	$1,950.00
Total Annual Repairs		$2,701.39

Repair cost estimates using the Selley procedure are given next. Repairs and maintenance are estimated on an hourly basis using the coefficients found in Table 5.7.

Repair Costs - Selley Procedure

Item	Rate	Hourly Cost
Power Unit	$.62/bhp/1,000 hr	$0.05
	20 hrs labor/1,000 hr @ $15/hr	$0.30
Delivery System	($0.08) (Pivot length/125)	$0.83
Total/Hour		$1.18

Assuming an annual use of 1,000 hours per year, the McGrann et al. procedure yields an estimate of $2.70 per hour, more than two times the estimate of Selley. Even if the lower end of the repair cost range from Table 5.6 is used, the McGrann et al. procedure yields an annual estimate of $2.05 per hour for the system, still significantly higher than the Selley method.

Energy Cost Estimates

McGrann et al. use the following procedure to estimate energy costs.

$$
\begin{aligned}
WHP &= (GPM)\,\frac{(FEET + [(PSI)\ (2.31)])}{3960} \\
TBHP &= \frac{WHP}{(PE)\ (GDE)} \\
PHRS &= \left(\frac{ACIN}{GPM}\right)(452.57) \\
TFU &= \frac{(2547)\ (PHRS)\ (TBHP)}{(BTU)\ (EE)} \\
FC &= (TFU)\ (FCOST)
\end{aligned}
\qquad \textbf{(5.23)}
$$

where

WHP = water horse power
GPM = gallons per minute pumped from well
FEET = static water depth

PSI = system pressure, in pounds per square inch
TBHP = brake horse power
PE = pump efficiency
GDE = gear drive efficiency (equals 1 for non-turbine)
PHRS = engineering estimate of annual use
ACIN = total acre inches pumped
TFU = annual fuel use
BTU = BTU's per unit of fuel
EE = engine efficiency
FC = total fuel cost
FCOST = cost per unit of fuel.

Table 5.9 gives the efficiency of irrigation components and Table 5.10 gives the BTU energy for the typical fuel alternatives. The energy cost estimates for the McGrann et al. procedure follow. The system is a low pressure center pivot system (800 gallons/minute, 35 PSI, 130 acres, 250' well, 200' column, 125' lift, and 206' head). The pump is driven by a 75 bhp electric motor and electricity is $0.08 per KWH. Costs are estimated for one hour of use.

Energy Cost for Center Pivot Irrigation System
McGrann et al. Procedure

$$WHP = (800)\frac{(125+(35)(2.31))}{3{,}960} = 41.58$$

$$TBHP = \frac{41.58}{(.75)(1.0)} = 55.4$$

$$PHRS = \left(\frac{1.77}{800}\right)(452.57) = 1.00\ hour$$

$$TFU = \frac{(2{,}547)(1.00)(75)}{(3{,}410)(.87)} = 64.39\ KWH$$

$$FC = (64.39)(0.08) = \$5.15/hour\ .$$

The water horsepower required for the system is 41.58. This converts to a brake horsepower requirement of 64.39. Because this is less than the 75 brake horsepower engine specified, the engine size is adequate. Because the goal is to estimate costs for one hour, the acre inches, 1.77, are chosen so that the hours required equals 1.00. The hourly energy use is 64.39 KWH, which costs $5.15 per hour.

Thompson and Fischbach and Selley estimate energy consumption for irrigating from the water horse power (WHP) requirement of the irrigation system. The WHP is estimated for all system types except center pivot as follows.

$$WHP = \frac{(Head)\ (GPM)}{3{,}960} \tag{5.24}$$

where

WHP	=	water horse power
Head	=	lift + (system pressure) (2.31)
GPM	=	gallons per minute system delivery.

For center pivots, WHP is estimated as

$$WHP = \frac{(Head)\ (GPM)}{3{,}960} + \frac{(.30)\ (PL)}{125} \tag{5.25}$$

where

WHP	=	water horse power
Head	=	lift + (system pressure) (2.31)
GPM	=	gallons per minute system delivery
PL	=	pivot length in feet.

Energy consumption is estimated as

$$EC = \frac{WHP}{EM} \tag{5.26}$$

where

EC	=	energy consumed per hour of operation, (gallons, kwh, or mcf depending on energy source)
WHP	=	water horse power
EM	=	energy use multiplier for energy type.

The energy use multipliers for each type are the following:

$$
\begin{aligned}
EM_{diesel} &= 12.5 \\
EM_{electric} &= .885 \\
EM_{lpg} &= 6.89 \\
EM_{natural\ gas} &= 61.7 \\
EM_{gasoline} &= 8.66
\end{aligned}
\qquad \textbf{(5.27)}
$$

where

EM_{diesel} = energy multiplier for diesel engines, gallons
$EM_{electric}$ = energy multiplier for electric motors, kwh
EM_{lpg} = energy multiplier for lpg engines, gallons
$EM_{natural\ gas}$ = energy multiplier for natural gas engines, mcf
$EM_{gasoline}$ = energy multiplier for gasoline engines, gallons.

Energy costs can be estimated by taking the energy consumption per hour and multiplying this by the per unit energy cost. This can then be annualized by taking the per hour cost and multiplying by the annual hours the irrigation system is used. Per acre costs can be calculated from this by dividing the annual cost by the number of acres irrigated by the irrigation system.

The per hour cost of irrigation is given by

$$E\$H = (EC)\ (FC) \qquad \textbf{(5.28)}$$

where

E$H = energy cost per hour of system use
EC = energy consumed per hour of operation
FC = fuel cost per unit, (gallon, kwh, mcf).

The annual cost of irrigation is computed as

$$AE\$ = (E\$H)\ (AH) \qquad \textbf{(5.29)}$$

where

AE$ = annual energy cost for system use

E\$H = energy cost per hour of system use
AH = annual hours of system use,

and per acre costs are given by

$$E\$A = \frac{AE\$}{Acres} \tag{5.30}$$

where

E\$A = annual energy cost per acre for system
AE\$ = annual energy cost for system use
Acres = acres of land irrigated with system.

The energy cost estimates for the Selley procedure follow. The system is a low pressure center pivot system (800 gallons/minute, 35 PSI, 130 acres, 250′ well, 200′ column, 125′ lift, and 206′ head). The pump is driven by a 75 bhp electric motor and electricity is \$0.08 per KWH. Costs are estimated for one hour of use.

Energy Cost for Center Pivot Irrigation System
Selley Procedure

$$WHP = \frac{(206)\ (800)}{3{,}960} + \frac{(.30)\ (1{,}290)}{125} = 44.71$$

$$EC = \frac{44.71}{.885} = 50.52\ KWH$$

$$E\$H = (50.52)\ (0.08) = \$4.04\ per\ hour\ .$$

The water horsepower required for the system is 44.71. Selley estimates energy use based on the water horsepower required. The water horsepower, 44.71, is divided by a fuel consumption multiplier, .885, to determine the units of energy consumed. The fuel consumed, 50.52 KWH costs \$0.08 per KWH and results in an energy cost of \$4.04 per hour of pump use.

Irrigation Lubricant Costs

McGrann et al. do not estimate a separate lubricant cost for the irrigation system. Selley estimates oil consumption as

$$OC = \frac{WHP}{OPU} + \frac{WHP}{OGD} \qquad \textbf{(5.31)}$$

where

OC	=	oil consumed per hour of operation, gallons
WHP	=	water horse power
Hours	=	hours system is used
OPU	=	oil multiplier for power unit
OGD	=	oil multiplier for the gear drive.

Appropriate coefficients for OPU and OGD are

$$\begin{aligned} OPU_{diesel} &= 900 \\ OPU_{electric} &= 4{,}000 \\ OPU_{lpg} &= 800 \\ OPU_{natural\ gas} &= 800 \\ OPU_{gasoline} &= 800 \\ OGD &= 4{,}000 \end{aligned} \qquad \textbf{(5.32)}$$

where

OPU_{diesel}	=	oil multiplier for diesel engines, gallons
$OPU_{electric}$	=	oil multiplier for electric motors, gallons
OPU_{lpg}	=	oil multiplier for lpg engines, gallons
$OPU_{natural\ gas}$	=	oil multiplier for natural gas engines, gallons
$OPU_{gasoline}$	=	oil multiplier for gasoline engines, gallons
OGD	=	oil multiplier for the gear drive, gallons.

Lubrication cost can be estimated similar to energy costs. The per hour costs are given by

$$L\$H = (OC)\,(O\$) \qquad \textbf{(5.33)}$$

where

L$H	=	lubrication costs per hour of system use
OC	=	oil consumed per hour of operation
O$	=	oil cost per gallon.

Annual lubrication costs for the system are computed by multiplying per hour costs (L$H) by annual hours of use (AH)

$$AL\$ = (L\$H)\,(AH)\,. \qquad \textbf{(5.34)}$$

Per acre costs are computed as

$$L\$A = \frac{AL\$}{Acres} \qquad \textbf{(5.35)}$$

where

L$A	=	lubrication costs per acre
AL$	=	annual lubrication cost for system use
Acres	=	acres of land irrigated by system.

The Selley procedure is used to estimate lubricant cost using the same example as previously. The required water horsepower, 44.71, is divided first by the power unit lubricant multiplier and then by the gear drive lubricant multiplier. Electric systems do not require a gear drive, thus, the second term of the equation, OC, is not used.

Lubricant Cost—Selley Procedure

$$\text{OC} = \frac{44.71}{4{,}000} = 0.011 \text{ gallons per hour}$$

$$\text{L\$H} = (0.011)\,(15) = \$0.165 \text{ per hour}\,.$$

The gallons of lubricant is estimated at .011 gallons per hour. If lubricants cost $15.00 per gallon, the lubricant cost is $0.165 for each hour the pump is used. The combined fuel and lubricant cost for the example is $4.21 ($4.04 + $0.17) for each hour the pump is used.

The two methods of estimating fuel and lubricant costs differ because McGrann et al. use the total brake horsepower (TBHP) to estimate energy consumption whereas Selley uses water horsepower (WHP). If 56.25 WHP were used in Selley's equations, or if 55.40 TBHP were used in McGrann et al.'s equations, the two methods would give very similar results.

TABLE 5.6 Annual Maintenance and Repairs for Irrigation Equipment

Component	Annual Maintenance and Repairs % of Initial Cost	Component	Annual Maintenance and Repairs % of Initial Cost
Wells and casings	.5 - 1.5	Pipe, asbestos - cement and PVC buried	.25 - .75
Pumping plant		Pipe, aluminum, gated, surface	1.5 - 2.5
Structure	.5 - 1.5	Pipe, steel, waterworks class, buried	.25 - .5
Pump, vertical turbine		Pipe, steel, coated and lined, buried	.25 - .5
Bowls	5 - 7	Pipe, steel, coated, buried	.5 - .7
Column, etc.	3 - 5	Pipe, steel, coated, surface	1.5 - 2.5
Pump, centrifugal	3 - 5	Pipe, steel galvanized, surface	1 - 2
Power transmission		Pipe, steel, coated and lined, surface	1 - 2
Gear head	5 - 7	Pipe, wood, buried	.75 - 1.25
V-belt	5 - 7	Pipe, aluminum, sprinkler use, surface	1.5 - 2.5
Flat belt, rubber and fabric	5 - 7	Pipe, reinforced plastic mortar, buried	.25 - .5
Flat belt, leather	5 - 7	Pipe, plastic, trickle, surface	1.5 - 2.5
Prime movers		Sprinkler heads	5 - 8
Electric motor	1.5 - 2.5	Trickle emitters	5 - 8
Diesel engine	5 - 8	Trickle filters	6 - 9
Gasoline engine, air cooled	6 - 9	Land grading	1.5 - 2.5
Gasoline engine, water cooled	5 - 8	Reservoirs	1 - 2
Propane engine	4 - 7	Mechanical move sprinklers	5 - 8
Open farm ditches	1 - 2	Continuously moving sprinklers	5 - 8
Concrete structures	.5 - 1		

Source: McGrann et al.

TABLE 5.7 Repair and Maintenance Costs of Power Units

	$/BHP/1,000 hrs	Hrs Labor/1,000 hrs
Diesel	5.00	20
Electric	.62	20
Propane, Natural Gas	2.40	40
Gasoline	3.15	40

Source: Selley.

TABLE 5.8 Delivery System Repair and Maintenance Cost Per Hour

System Type	$/hr
Pivot	.08 x Pivot length/125
Gated Pipe	$.02 \times \sqrt{acres}$
Side Roll	$.04 \times \sqrt{acres}$
Skid Tow	$.04 \times \sqrt{acres}$
Big Gun	$.08 \times \sqrt{acres}$
Reuse	$.02 \times \sqrt{acres}$

Source: Selley.

TABLE 5.9 Energy Use Efficiency of Irrigation Components

Item	Engine Efficiency (%)
Electrical Engine	
< 20 HP	91
> 20 HP	87
Diesel Engine	32
Natural Gas Engine	28
Gasoline Engine	
Air Cooled	26
Water Cooled	26
Propane Engine	28
	Pump Efficiency (%)
Centrifugal Pump	75
Turbine Pump Discharge Head	75
	Gear Drive Efficiency (%)
Gear Drive	
Right Angle	95.0
Direct	100.0
Belt, V-Belt	92.5
Flat Belt	87.5

TABLE 5.10 BTUs of Energy Per Unit of Fuel

Energy Source	BTU	Unit
Diesel	135,250	gallon
Electricity	3,410	KWH
Gasoline	124,100	gallon
LP Gas	92,140	gallon
Natural Gas	1,000,000	MCF

BUILDING AND EQUIPMENT OPERATING COSTS

Klonsky (1992) conducted a survey on data and methods used to develop enterprise budgets by land grant universities. Only 54% of those surveyed included building costs in enterprise budgets. In general, only buildings that could be charged entirely to a specific enterprise (for example, livestock buildings) were included. Buildings for equipment and/or shops were almost never included. Of those that included building costs, no data were collected on the repair of these buildings. Operating costs for buildings, including repairs and maintenance, could be obtained from general producer surveys, but would probably require specialized surveys designed to track such expenditures. Data on specialized buildings such as finishing units may be available from manufacturers, specialized farm record keeping systems, farm management consultants, or practicing agricultural engineers. Doane estimates repair and maintenance of buildings at 2-3% of original purchase or construction cost. Construction (purchase) costs for buildings might come from surveys, appraisal guides, or records of real estate transactions. More discussion of valuing the capital costs of buildings and equipment is contained in Chapter 6.

Operating costs for equipment, here defined as items other than farm machinery, are also difficult to estimate. Examples of items in this category are fencing, waterers, milk coolers, feed bins, feeding systems, etc. Often, these items are considered part of overhead and might not appear directly in the CAR estimate. Engineering estimates for repair and maintenance are usually specified as a percent per year of initial list price (Kletke). Where equipment is used by multiple enterprises, the costs must be allocated to the enterprise, and if the CAR estimate is being developed on a per head basis, the costs must be further allocated. The equipment items are so diverse that when they are estimated using surveys, they will generally be part of overhead. Whether building and equipment costs are estimated directly or included as part of overhead, CAR estimate developers should be certain that these costs are included.

INTEREST ON OPERATING COSTS (EXPENDABLE INPUTS)

All users of CAR estimates agree that interest should be included. Some view the interest as cost of funds used. Others view interest as an adjustment of all costs to a point in time. There is also some difference of opinion about whether the interest charge should be actual interest paid to lenders, full nominal opportunity interest, or real opportunity interest. The amount of interest charged should be based on the purpose of the CAR estimate, the amount of capital invested, and the appropriate rate of interest. Historical CAR estimates used for evaluating the financial position of operators may include only interest paid to lenders whereas CAR estimates used to develop and compare alternative government programs should include the full opportunity cost of capital. Cost and return estimates used for short-term cash flow planning may include interest expected to be paid to lenders whereas CAR estimates used for enterprise evaluations and comparisons should include the full opportunity cost of capital.

As discussed in Chapter 2, nominal interest should be charged on all operating costs incurred during the production period. In essence, the interest charge adjusts all costs to a single point in time. Costs and returns that occur at the CAR estimate termination date should not be charged interest. If costs occur at other than the CAR estimate termination date, interest should be charged to adjust these costs to the termination date.

Developing a framework for estimating interest requires that CAR estimate developers clearly state the use of the CAR estimate and the assumptions regarding interest charges.

Interest Rate Definitions

Financial interest: dollar amount paid to lenders for the use of funds.

Nominal opportunity interest rate: imputed interest charge reflecting nominal income foregone as a result of investing in the current enterprise. In the context of CAR estimates, the nominal opportunity cost is used to adjust a CAR estimate to the CAR termination date.

Real opportunity interest: imputed interest charge reflecting real income foregone as a result of investing in the current enterprise. In the context of CAR estimates, the real opportunity cost is used to adjust a CAR estimate from the current period to other periods and from other periods to each other.

Estimating Interest for Historical CAR Estimates

Historical CAR estimates can have two basic purposes: determining the actual cash costs of operating an enterprise or determining the economic costs of producing a unit of the enterprise. Historical CAR estimates are usually prepared by (a) the USDA Economic Research Service from surveys, and (b) universities that have records available from which to estimate the historical costs of production.

Actual cash operating interest is the financial interest charge paid to a lender. This would ideally be determined by survey: however, most operators do not have records that would permit precise allocation of interest charges to CAR estimates for a particular enterprise. In ERS cost of production estimates, whole-farm interest is allocated to the farm enterprises.

The historical CAR estimates prepared by ERS to estimate the economic costs of production use a combination of surveys and opportunity cost charges to estimate cash interest costs. The amount of operating capital invested in an enterprise is determined by survey and the charge for using that capital is an opportunity charge. The imputed cost of operating capital is based on the concept that rational producers expect the capital invested in variable production inputs to earn at least as much as funds invested in a savings account or some other interest-bearing financial instrument with similar risk. ERS currently uses a six-month Treasury bill rate as the opportunity interest charge (Morehart et al., Agricultural Handbook No. 671, 1992). More discussion of appropriate opportunity interest rates is contained in Chapter 2.

Estimating Interest for Projected CAR Estimates

Interest charges included in projected CAR estimates are determined by three identifiable components: the amount of money invested or expended, the rate of interest, and the length of time the money is tied up in the investment or expense. Estimating the amount of money on which interest must be paid requires knowledge of when expenditures are made and the termination date of the enterprise for a particular cost and return estimate. As stated in Chapter 2, **the Task Force recommends that projected CAR estimates establish the end of the production period as the reference point in time and that all expenditures and revenues be accumulated to the end of the production period**. Most CAR estimates are currently prepared using an opportunity interest rate because estimating cash interest payments to lenders requires knowledge of the operator's equity position.

Three alternative ways of determining the interest charge with advantages and difficulties for each are discussed here. Determining whether to use nominal or real interest rates further complicates the alternatives considered.

Alternative 1

A nominal rate of interest is used in this alternative. The approach assumes that the operator will borrow or charge at a nominal opportunity cost for all operating capital. The advantages of this rate are simplicity and understandability. Farm operators understand the charge and even if they do not borrow all the funds on which the charge is made, they understand the opportunity concept being used. A difficulty is specifying what the nominal rate should be. Alternatives include (a) a rate of interest that farm operators might pay for funds; (b) a rate of interest that farmers might receive for funds if an alternative investment had been chosen; and (c) a weighted average of the rate actually paid for funds on the amount actually borrowed and the rate the operator would receive on funds invested in other alternatives for funds not actually borrowed. The correct choice for most applications is the second one that reflects the opportunity cost of invested funds. The most common alternative nominal rate used, as discussed in Chapter 2, is the risk- and inflation-adjusted long-term real rate of interest.

Crop CAR estimates usually terminate at the point of first transfer of a salable product and this is normally the time at which interest charges terminate. With crop and livestock enterprises having multiple production periods (alfalfa and dairy cows for example), a time point must be chosen arbitrarily to terminate interest charges. This is usually the end of a calendar year or the end of a production cycle.

After the appropriate rate is chosen, the nominal interest charge for the j^{th} expense C_j (incurred n_j months from the terminal point of the estimation procedure) would be calculated as

$$(interest\ charge)_j = C_j(1+i)^{\frac{n_j}{12}} - C_j \tag{5.36}$$

where i is the annual nominal interest rate. The total of all interest charges can be computed as

$$interest\ charge = \sum_{j=1}^{m}\left(C_j(1+i)^{\frac{n_j}{12}} - C_j\right) \tag{5.37}$$

where m is the number of expenses on which interest is charged. In a similar fashion if an enterprise has returns that occur before the terminal point in the year, they should also be adjusted to this terminal point using the same nominal interest rate.

Alternative 2

This method computes interest based on the per period rate and the applicable proportion of the period. This means that if the interest rate is stated as an annual level, the rate for different subperiods will be the proportion of the year over which the cash flow is discounted, multiplied by the annual rate. Specifically, for an expense incurred n months before the terminal date of the enterprise, the approximate interest charge is

$$\begin{aligned}(interest\ charge)_j &\approx C_j[1+(\frac{n_j}{12})(i)] - C_j \\ &= C_j(\frac{n_j}{12})(i)\end{aligned} \tag{5.38}$$

where n_j is the number of months until the enterprise terminates. This method gives a higher interest charge than alternative 1 because the implied subperiod interest rate is higher than the actual rate computed in alternative 1.

This procedure can be modified for several conventions common in estimated CAR interest computations. One convention often used is to charge interest on expenditures for a fixed period, say six months, for all capital used. This implies that all n_j would be equal to the chosen proportion of the year. When it is assumed that all capital is invested for a certain length of time, say six months, the interest charge can be calculated by multiplying the total capital by 6/12 and multiplying the result by the annual interest rate. Although this approach may not be as precise as charging interest on each item for the length of time the capital is invested, it does provide a reasonable approximation for the cost of capital. Another convention sometimes used is to charge interest from the time of input use until a specified date other than termination date. For these situations n_j becomes the portion of a year elapsing from the time the input is purchased until the chosen date.

Alternative 3

A procedure using both real and nominal interest rates is to use the inflation rate to inflate the expense and income items to the chosen time period (Walker and Kletke) and then apply a real interest rate to these expenditures. As discussed in Appendix 2A, the appropriate adjustment for each income and expense item is

$$\begin{aligned} (\textit{inflation adjusted cost})_j &= C_j^{\mathrm{p}} = C_j\,(1+\mathrm{p})^{n_j/12} \\ (\textit{inflation adjusted revenue})_k &= R_k^{\mathrm{p}} = R_k\,(1+\mathrm{p})^{n_k/12} \end{aligned} \tag{5.39}$$

where

C_j	=	cost of input item j
C_j^{p}	=	inflation-adjusted end of year cost for item j
R_k	=	revenue from output k
R_k^{p}	=	inflation-adjusted end of year revenue for item k
p	=	rate of inflation
n_j , n_k	=	months of year the capital is invested.

After all costs and revenues are adjusted for inflation, the real cost of capital is computed using a real rate of interest. For each input the real rate of opportunity interest expense should be charged on each input for the period of time from purchase or use until termination of the CAR estimate, as in equation 5.36. Likewise, for each revenue item, there should be an opportunity interest income from the time the income is received until enterprise termination. This will then give

$$\begin{aligned} (\textit{Real opportunity interest expense})_j &= C_j^{\mathrm{p}}\,(1+r)^{n_j/12} - C_j^{\mathrm{p}} \\ (\textit{Real opportunity interest revenue})_k &= R_k^{\mathrm{p}}\,(1+r)^{n_k/12} - R_k^{\mathrm{p}}. \end{aligned} \tag{5.40}$$

These individual items can then be summed to obtain a net real opportunity interest expense as

$$\textit{Net real opportunity interest expense} = \sum_j \left(C_j^{p} (1 + r)^{n_j/12} - C_j^{p} \right) - \sum_k \left(R_k^{p} (1 + r)^{n_k/12} - R_k^{p} \right). \qquad \textbf{(5.41)}$$

For crops with a single production point, there will be no inflation or opportunity interest income on the revenue from production as long as sales come at the end of the period. For multiple production period crop and livestock enterprises, the value of production income must be adjusted for inflation and then receive a real rate of opportunity interest. The net of opportunity interest income and expense would be the net interest charge (income) for the CAR estimate. The CAR estimate termination point for multiple production period enterprises could be either the time of physical transfer of the last salable product, the end of the calendar year, or some other arbitrarily selected date.

Comparison of Alternatives

Variations of alternatives one and two are the most common ways of determining interest charges on CAR estimates. The rate of interest used is nominal and might be a weighted average of financial interest on borrowed capital and opportunity interest on operator-provided capital, or it might be opportunity interest only. Alternatives one and two use the nominal interest rate as a starting point, whereas alternative three requires knowledge of both inflation and real interest rates. Although both alternatives one and three are theoretically correct, alternative one is the most easily understood and is generally preferred by CAR estimate developers.

The distinct advantage of alternative three is having real interest determined separately from inflation. This permits the CAR estimate developer to not include inflation as an expense. There are, however, operational difficulties with alternative three. Although conceptually correct, there are numerous computations required. Also, accurate specification of inflation rates and real interest rates is required. Another concern is explaining the interest charge to farm operators and other CAR estimate users. Many users of CAR estimates understand the nominal rate of interest when it is related to what they pay for capital, particularly when interest is being paid to a lending institution. It is difficult to explain that the nominal rate is really composed of a real interest component and inflation and that only real interest should be considered. For more discussion of interest costs see the examples in Chapter 2, Tables 2.2-2.4.

CUSTOM OPERATIONS AND CUSTOM RATES

Definition

A custom operation is defined as the joint hiring of machinery, labor, and in some cases, purchases of materials to perform a production operation. Examples of crop operations are fertilizer application, land preparation, seeding, spraying, cultivating, harvesting, and hauling. Typical custom livestock operations are feed mixing, sheep shearing, and manure hauling and spreading. Custom operations could include all, none, or several of the tasks performed in the production of the product. Examples where all tasks are custom include custom crop farming or custom feedlots for finishing cattle. The charges for custom operations are commonly called custom rates.

Overview of Issues

Almost any task in production agriculture can be performed as a custom operation. Whether or not it is appropriate to use custom rates for CAR estimation depends on their purpose. When the intent is to determine the full cost of production, it may not be appropriate to use a custom operation unless it is typically performed by a custom operator and it is believed that the custom charge fully covers the operating and ownership costs of the custom operator. When the intent of the CAR estimate is to aid in financial decisions, or enterprise selection, it may be appropriate to use typical custom rates for any or all tasks. When CAR estimates are being prepared for individual farm decision makers, it is expected that the lowest cost alternative for acquiring a service would be used.

There are situations where local farmers do custom work for their neighbors, receiving some non-pecuniary benefits in lieu of, or in addition to, charging only what is necessary to cover their variable costs. Using these custom rates would underestimate actual production costs. If the custom operator is a neighboring farmer who does custom work after completing his own tasks, less timely operations could reduce output and profitability. If appropriate, yield adjustments should be made.

The size and type of farm operation determines the feasibility of using custom operators. Small crop, livestock, and dairy operations often cannot justify a large investment in agricultural machinery and equipment when both the money and the use of the capital items are limited. In these situations, it is more economical for small farm operators to rely on custom operations instead of owning the equipment and performing the activities themselves. At the same time, some small operators may have access to low cost equipment that would not be suitable for a larger operator.

Larger operations may often use custom operators for specialized tasks (for example, aerial spraying or seeding, soil fumigation, crop harvesting, or manure pit pumping and spreading) in the business. Agribusiness firms specializing in these operations are usually used by larger businesses. The custom operator may provide timeliness of operation, lower cost of investment, specialized skills, and/or unique equipment for the operation.

It is usually desirable for all materials used in enterprise production to be listed with the CAR estimate. However, when custom operators are used for labor-intensive harvesting operations, or when they provide specialized services, it may be difficult to divide the custom charge into costs of materials, labor, management, and custom operator profit. Where possible, custom charges should be divided into components, but when not feasible, it is permissible to include a custom charge for the complete custom activity. Listing of materials is particularly important for fertilizer, pesticides, and other cost items that may critically affect the production level or impact the social acceptability of the enterprise.

Current Procedures

Historical CAR estimates are obtained from surveys of farm operators. Because surveys include both operators who have and do not have custom work performed on their operations, the CAR estimate may include tasks that are part custom and part operator performed. Custom expenses in ERS CAR estimates are estimated from data reported in the Agricultural Resource Management Study (ARMS). Some states also perform surveys to determine costs of production.

Projected CAR estimates developed by land grant university extension and research staff, and others, are based on a composite of farm record program summaries, producer panels, cost estimation equations, and the expectations of expert panels. In projected CAR estimates, each operation will usually be performed either by the farm operator or a custom operator, but not a mixture of the two. If there are operations where custom operators are typical and where operators also perform the operation, multiple enterprise CAR estimates can be developed to reflect the different practices.

Custom rates per unit of production (planted acre, breeding animal, and hundredweight of products) are estimated by dividing the total custom expense by the number of planted acres, the number of breeding animals, or number of units of product. Where custom operations are performed by profit-oriented custom operators, custom rates can be used as a proxy for the operating and ownership costs of a specific operation or a series of operations in the enterprise.

Recommended Procedure

Custom operations should be appropriate for the intended use of the CAR estimate. **When full costs of production are being estimated, custom charges can be used when it is believed that the charge includes the full ownership and operating costs of the operation.** However, if the custom operator is not profit motivated and the resulting custom rate does not cover operating and ownership costs, then using the custom rate would underestimate the true cost of production. **Materials and labor requirements should be listed unless the custom operator cannot accurately divide the amount charged into components.** It is particularly important to list amounts and types of fertilizer, pesticides, and other inputs that may affect the production quantity or enterprise desirability.

On small farms, custom charges may be appropriate because operators can lower their costs by hiring tasks performed. (Developers of CAR estimates should be certain that the charge includes ownership and operating costs.) On large farms, custom operations may occur because custom operators can provide specialty services in a timely fashion less costly than the operator can perform the task(s).

When ownership and operating costs for a production practice are difficult to estimate directly, custom rates might be used as a proxy to estimate the costs for a specific production input, even though the operator might perform the task. This procedure should be avoided if at all possible, because the actual costs to the operator might be either higher or lower than the custom charge.

OTHER COMMODITY-SPECIFIC COSTS

There are numerous costs which must be dealt with on an item-by-item basis. These costs can be divided into several groups having similar characteristics. Following is a discussion of the groups and some of the characteristics of costs in each group. This section concludes with a discussion of examples for each cost group.

The purpose of developing generalized CAR estimates is to provide information that will be useful for the many alternative uses made of CAR estimates. It is essential that costs reflect the actual and full costs of performing a task or providing a service. With this in mind, costs included in this section should include both direct costs to the producer as well as reductions in prices received because of involuntary checkoffs or marketing charges. Cost and return estimates should provide sufficient information so that either net returns to producers or economic costs of production can be estimated.

General Guidelines

- If possible, cost items should not be subtracted from the commodity price. For example, transportation costs should not be subtracted from the price of the product, but included as a cost. The reported product price should be the price before any costs are deducted.

- If it is not possible to have the cost items separated from the commodity price, the CAR estimate must indicate clearly which cost items have been included in the price.

- Where possible, costs should be separated into basic components. For example, production costs should be separated from marketing costs.

- Costs should be specified so that users can observe whether they vary by the amount of production or are set for the unit of production. For example, hauling charges for wheat should be so much per bushel times the number of bushels produced rather than entered as a total hauling cost per acre. If the cost of an item varies with the number purchased or marketed (such as quantity discounts or premiums) the price and quantity assumed for the estimate should be reported.

- Costs reported should include both ownership and operating components. When services are purchased, costs should include the full cost of providing the service.

- The cost of an input should be the cost expected at the time of application or use and not necessarily at the time of purchase. If a producer typically purchases an input prior to its use, this purchase cost should be adjusted to the time of use to make it compatible with other inputs applied at the same time. All the costs of a given production operation (such as machine time, labor, and seed for planting) should then be adjusted to the end of the production period.

- Costs for inputs providing benefits for more than one production cycle should have their costs spread over the duration of the benefit. Further discussion of how to do this is contained in Chapter 10: Allocating Preproductive Costs for Multiyear Enterprises.

- Costs should reflect the most common practices in a region, and CAR estimates prepared with other assumptions should be identified clearly.

- If costs are not evenly distributed between systems, multiple CAR estimates should be prepared (irrigation vs. nonirrigation, reduced vs. no-till).

- Footnotes to the CAR estimate, or accompanying text, should provide sufficient information for readers to understand assumptions and procedures for estimating costs.

Costs for Operations Which Can Be Completed Either On-Farm or Commercially

Examples of this type of cost include storage, drying, ginning, sheep shearing, and transportation. Many producers do not have the equipment or facilities to perform these tasks and, for these operations, the only alternative is to have them performed commercially. When CAR estimates are prepared for producers having the capability of performing these operations, all costs (ownership and operating) related to these activities should be included. Additionally, for costs such as storage, the expected shrinkage and spoilage in the amount of product to be sold should be specified.

Costs for Services or Commodity-Specific Supplies

Examples include marketing charges and cartons, bags, tags, and so forth. Products sold frequently during the year often require employing an agent to assist in marketing the product. Commissions paid to the agent are typically commodity specific. The marketing of many fruit or vegetable products requires the purchase of bags or cartons for packing the product. These costs should be specified so that the user of the CAR estimate has the most information possible.

Costs Required for Obtaining the Rights to Produce or Sell Farm Products

Examples include quotas, permits, involuntary checkoffs, certifying crops as organic, and marketing order assessments. These costs are typically set by law or agreements among producers. Some costs may be based on the production unit (acre or head), others on the units produced (bushels or cwt.). Whatever the charge, the impact on CARs should be reflected as a cost item rather than a reduction in sales price. A more complete discussion is contained in Chapter 9.

Crop Insurance

When a crop insurance coverage level is chosen, a minimum level of production is guaranteed. This guaranteed minimum production will reduce income variability and cause the expected production from the enterprise to have an average somewhat greater than the guaranteed crop insurance minimum. Over time and in aggregate, it is expected that the proceeds from crop insurance will equal the cost of crop insurance less the cost of managing the crop insurance program. Thus, over time, one would expect the net proceeds from crop insurance to be slightly less than the costs unless the program is being subsidized. Any time crop insurance is included in a CAR estimate, the CAR estimate developer should ensure that the cost of crop insurance exceeds the expected proceeds unless the program is being subsidized.

How crop insurance is incorporated into CAR estimates depends on the use of the CAR estimate and what is typical in the area. Whenever crop insurance is included as a cost, care should be exercised to ensure that the income level reflects the expected reduction in variability (and resulting increase in average production). Whether crop insurance proceeds are handled as an entry separate from production is up to the developer. But, information provided with the CAR estimate must be explicit so that CAR estimate users are informed adequately. Also, coverage level assumptions and any other information needed to identify costs and benefits accurately should be stated. See also the subsection in Chapter 3 entitled Commodity Loss or Damage Insurance.

Selected Commodity-Specific Costs

Drying Costs

- Do not net from sales price.

- Use commercially available rate per unit of production or estimate all costs (ownership and operating) for on-farm drying.

- Commercial rates will typically be on a per unit produced basis. In some cases the per unit charge may vary directly with the amount of moisture removed.

- On-farm drying costs require estimating ownership costs as well as determining fuel usage and labor requirements for drying the typical amount of production for an acre.

- Assumptions and procedures used for estimating costs should be summarized in a footnote or accompanying text.

Storage Costs

- Storage costs are not expected in most situations since CAR estimates terminate at the point of first physical transfer of a salable product. Thus, storage costs are expected only if storage is required to assemble a salable product.

- If it is necessary to store crops, either commercially available off-farm storage or on-farm storage may be used.

- Storage costs should only be included until the CAR estimate is terminated (point of first transfer).

- Off-farm storage will normally be charged at a per unit of production per unit of time (cents/bushel/month) rate.

- On-farm storage will require estimating ownership and operating costs for the storage facility. Operating costs should include labor and any fumigants or other chemicals typically used in grain storage.

- Shrinkage and spoilage are associated with on-farm storage. The loss of production units (bushels) due to shrinkage and/or spoilage depends on time of storage. For commodities stored, the amount of production loss due to shrinkage and spoilage should be stated and subtracted from the stated field yield so that the amount of product sold can be specified accurately.

- Assumptions used for estimating storage costs should be summarized in a footnote or accompanying text.

- Storage costs for inputs purchased preseason should be included if significant.

Transportation Costs

- Because CAR estimates typically terminate at the point of first product transfer, transportation costs may or may not be necessary. For products sold in the field or livestock sold at the farm gate, no transportation charges should be included. For products and livestock delivered to a central point, transportation charges to that point should be included.

- Transportation can be performed either by the operator or as a custom operation.

- Custom transportation is often provided with custom grain harvesting operations. Usually, the transportation charge is made separately from the harvesting charge. The cost will depend on the amount of production and the distance hauled.

- Commercial truckers are often used to transport livestock. Expected rates should be multiplied by weight to determine the expected hauling charge.

- For producers providing their own transportation, both ownership and operating costs must be included. Fuel, lubricants, repairs, and labor costs associated with transportation must be included to estimate the economic costs of production.

- Assumptions for estimating transportation costs should be summarized in a footnote or accompanying text.

- When commodity prices assume that transportation is provided by the buyer and it is impossible to separate the cost component, the price should be clearly identified as a field or farm gate price.

Ginning Costs

- The value of seed produced should not be used to offset ginning charges. As a result, it is necessary to include the sale of seed in the list of products produced.

- Normally, ginning costs will be available as a cost per unit of product. The cost per acre can be estimated by multiplying the ginning cost per unit by the number of units produced per acre.

- Assumptions for estimating ginning costs should be summarized in a footnote or accompanying text.

- Ginning costs are often charged on the basis of seed cotton (lint, seed, burrs, trash) prior to ginning. When this is done, one must factor in the ratio of seed cotton to lint in order to include ginning costs accurately.

Shearing Costs

- The cost of shearing sheep should be included as an expense and not deducted from the sales price.

- Shearing costs are typically on a per head basis.

- If the sheep CAR estimate is for a flock, the shearing costs for rams should be included.

- Assumptions for estimating shearing costs should be summarized in a footnote or accompanying text.

Marketing Charges

- Commissions for handling the marketing of crops and livestock should be typical for the commodity.

- Any fees charged for using facilities necessary to the marketing process should be included.

- Grading charges for fruits and vegetables should be included.

- For some commodities, particularly livestock, there may be marketing charges associated with purchasing an animal.

- Assumptions for estimating marketing cost should be summarized in a footnote or accompanying text.

Cartons, Bags, and Tags

- Some commodities, particularly produce, require bags or cartons that must be purchased.

- These costs will be based on the amount of production.

- Assumptions for estimating any costs for cartons, bags, tags, and so forth should be summarized in a footnote or accompanying text.

Involuntary Checkoffs

- Involuntary checkoffs should not be deducted from the sales price. Rather, they should be listed as a cost of production.

- Assumptions for estimating checkoff charges should be summarized in a footnote or accompanying text.

Marketing Order Assessments

- Assumptions for estimating marketing order assessments should be summarized in a footnote or accompanying text.

Permits and Quotas

- Assumptions for estimating permit and quota charges should be summarized in a footnote or accompanying text.

Crop Insurance

- Include crop insurance cost only if expected income is adjusted to reflect reduced variability associated with the purchase of crop insurance. The impact of indemnity payments on revenue can be included either by adjusting the yield or by including a line for the expected indemnity payment.

- Crop insurance can be either for a particular hazard to production or for all possible threats to production.

- Managers can choose the level of coverage appropriate to their situation.

- Assumptions on coverage levels, impacts on income levels, and cost estimation procedures should be summarized in a footnote or accompanying text.

CHAPTER 6

MACHINERY, EQUIPMENT, AND BUILDINGS: OWNERSHIP COSTS

INTRODUCTION

The objective of this section is to discuss issues and procedures related to estimating the cost of capital assets. Capital assets are factors of production that are not used up during a single production period, provide services over time, and retain a unique identity. The term **durable asset** is often used to describe **physical capital** because the word durable denotes not temporary or long-lived. Many durable assets such as machinery or buildings have reduced service capacity due to use and/or time. Some capital assets (breeding livestock, tile drains, windbreaks) may even be completely worn out or used up over a period of years.

There are many examples of durable assets in crop and livestock production operations. Land is perhaps the most significant durable factor of production for crops. It is an example of a unique nondepreciable durable asset. Land involves a point investment with a relatively constant flow of services over a very long, perhaps infinite, period. Land improvements such as terraces and land leveling may also involve a flow of service over an infinite period or in some cases provide service over a finite length horizon. In this latter case, these improvements would be classified as a durable factor of production (details associated with the costing of land are presented in Chapter 7). Similarly, the right to draw irrigation water from a particular stream is a capital (durable) asset in the sense that water can be withdrawn year after year. The primary focus of this section is on durable inputs, other than land, used in crop production. The most common durables in crop production are machinery, irrigation equipment, crop storage structures and equipment, and machinery storage structures. In livestock production the most routine durable inputs are the buildings and equipment used to house, care, and feed animals, and dispose of their waste. Breeding livestock are also considered durable inputs because they produce a flow of products (milk, offspring, wool, and so forth) and/or services (such as those provided by draft or riding animals) over multiple periods. Many durable inputs are used in multiple enterprises and require allocation of the ownership and use costs across the alternative production processes. A more complete discussion of such joint costs is contained in Chapter 9 entitled Joint Costs, General Farm Overhead, and Rights to Produce and in the final section of this chapter.

PRODUCTIVITY OF DURABLE ASSETS

As discussed in Chapter 2, a durable asset may provide different levels of service depending on its condition as represented by age, amount of previous use, service enhancement, and maintenance performed. It is common in preparing cost of production estimates to assume that durables such as machinery and buildings provide a constant quality of service over their lifetime with regular maintenance. This assumption is more appropriate for facilities and equipment that is properly maintained than for breeding livestock, perennial crops, and some types of land improvements. For these capital inputs and for machinery with highly variable productivity over time, the procedures discussed in Appendix 6A and Chapter 10 are more appropriate.

Chapter 6. Machinery, Equipment, and Buildings: Ownership Costs

TYPES OF COSTS

The major types of costs associated with asset ownership and use are the opportunity cost associated with the financial capital invested in the asset, reductions in value due to use and/or time, and changes in the market value of the asset during the period it is held. Other costs such as property taxes, housing, and insurance are generally much smaller.

Changes in Market Value

Changes in the market value of an asset can occur because of changes in its service capacity (quantity, quality, and reliability of service provided) and/or because of changes in the market price of the services it provides. If V_1 is the value of the asset at the end of a period and V_0 is the value at the beginning of the period, then the change in market value is equal to $V_0 - V_1$. This change in market value ($V_0 - V_1$) is called **economic depreciation (ED), which is defined as the change in the asset's present value as time passes, given the remaining, but shorter series of earnings and the given economic rate of return**. For an asset whose value declines over time, ($V_0 - V_1$) will be a positive number and reflect a positive cost. Reductions in the service capacity of an asset are considered first under the general topic of depreciation resulting from reductions in service capacity.

Depreciation Resulting from Changes in Service Capacity

The reduction in service capacity associated with time and use is a major ownership cost for most durable inputs. The flow of services a durable provides may decline over its life because of three components—time, use, and obsolescence. Among types of durables there is considerable difference in the relative importance of each of these components in explaining remaining values of an asset over its life. Once a specific asset is placed in use, the remaining value is dependent upon actual use, age, and technological change. For assets with active markets, this depreciation often can be observed in a reduced market value. If data are not readily available on the value of the remaining service potential of an asset during each period of its life, estimates of depreciation must be made. A particular level of remaining service potential is sometimes called the **use value** (UV) of an asset or the **remaining value** (rv) of the asset. The use value of an asset depends on many factors including the type and age of the asset, its expected useful life, its previous use, prior maintenance, housing provided, care exercised by the operator, and so forth. This multidimensional characteristic vector describing the use value of an asset is often approximated by an estimate of its remaining hours of "normal" service life where normal is a vague description of some modal type of service. The most common assumption for economic costing purposes is that the total decline in the value of potential service from the time the machine is purchased until it is sold is distributed evenly over the life of the asset. This is called **straight-line depreciation** and is given by **dividing the decline in use value over this total time by the number of years or periods**. This is given by

$$D_{sl}(j) = \frac{UV_0 - UV_n}{n}$$

where D_{sl} (j) is straight-line reduction in use value (depreciation) in the j^{th} year, UV_0 is the use value at the beginning of the first period, UV_n is the use value at the end of the n^{th} period, and n is the number of periods. Because the asset is held over the entire period, one can ignore interim declines in value (or profits) and consider the asset's entire life as a single decision unit (Levy and Sarnat). Straight-line depreciation usually assumes some fixed level of usage per year (which adds up to total use over several years) so that depreciation per year is dependent only on the passage of time. It is important if this annual level of use changes to modify both the total and the annual rate of depreciation.

Farm machinery, in particular, may not have this straight-line pattern but may have larger declines in remaining value during early periods of life (Robison and Barry, 1996: Chapter 9) due to time and obsolescence. A common approximation to this nonlinear pattern is the sum-of-the-years method of computing depreciation. This pattern is not necessarily recommended by this Task Force but illustrates well a non-linear pattern. The total depreciation over the life of the equipment is computed using the following formula for each year where n is the years the machine is owned between purchase and subsequent sale.

$$D_{sy}(j) = \frac{(n+1-j)}{\left(\frac{n(n+1)}{2}\right)}(UV_0 - UV_n).$$

In this formula, D_{sy} represents sum-of-the-years reduction in use value (depreciation) in the j^{th} year. This method, as with straight-line depreciation, while attempting to adjust for nonlinear changes in use-value, assumes that for given values of UV_0 and UV_1, depreciation each year is dependent only on the passage of time and does not take into account the effect of the amount of use in an individual year.

> **Example:** For comparison of the two methods consider a new tractor with a list price of \$70,000 where it is assumed that use value is measured in dollars. Assume that at the end of each year the tractor has the total hours of use with remaining value as shown in Exhibit 6.1. Also assume that the price for a tractor with a given age and hours of use is constant in real dollars. Assume that the farmer is planning on selling the tractor at the end of five years. Notice that in this example the decline in remaining value is related to time and not just use in terms of hours.

EXHIBIT 6.1

Remaining Value ($)	Age	Total Hours of Use	Depreciation Straight-line (SL)	RV (SL)	Depreciation Sum-of-the-years (SY)	RV (SY)
70,000	0	0		70,000.0		70,000.00
47,586	1	500	7,107.8	62,892.2	11,846.33	58,153.67
43,040	2	900	7,107.8	55,784.4	9,477.07	48,676.60
39,535	3	1,500	7,107.8	48,676.6	7,107.80	41,568.80
36,821	4	1,900	7,107.8	41,568.8	4,738.53	36,830.27
34,461	5	2,400	7,107.8	34,461.0	2,369.27	34,461.00

The total decline in use value is $35,539 (70,000 - 34,461). Straight-line depreciation assumes the machine has a constant decline in value of $7,107.80 per year. This gives the remaining values in the RV Straight-line column. The value at the end of five years is the same as the actual pattern of remaining values, but the values for each of the years are very different. Remaining values computed using sum-of the-years depreciation are in the last column of the table. The pattern is not uniform as with straight-line depreciation and seems to mimic the time pattern of remaining value somewhat better. As long as the machine is held over the entire period, the economic costs of either method over the five-year time horizon will be the same as is seen in the section entitled Procedures for Cost Estimation.

Another common technique for estimating depreciation, which is also acceptable for tax purposes, is the declining balance method. The declining balance method implies a geometric decline in value over time. A fixed rate of decline is applied to the value of the machine at the end of each year. The depreciation is computed recursively as follows

$$D_{db}(1) = (UV_0)(rd)$$

$$UV_1 = UV_0 - D_{db}(1)$$

$$D_{db}(2) = (UV_1)(rd)$$

$$UV_j = UV_{j-1} - D_{db}(j)$$

$$D_{db}(j) = (UV_{j-1})(rd)$$

where rd is a rate of depreciation expressed as a percent of the useful life of the machine and UV_j is the value of the machine at the end of the j^{th} year. This can also be written as

$$UV_j = UV_0 (1 - rd)^j .$$

With this method, the machine will never reach a zero salvage value and so it is not as applicable for estimating economic depreciation unless it is truncated. An alternative that is often used in practice is to use the double declining balance method of depreciation for the first few years of an asset's life and then switch to a straight-line method for the remaining years when the annual depreciation computed from the double declining balance method is less than the straight-line amount. This avoids the problem of the salvage value only going to zero in the limit.

Price Changes

An asset may also change in value due to changes in the price of a unit of the asset's service. For example, a steep rise in the price of sweet corn may lead to a rise in the price of used sweet corn harvesters, regardless of their remaining service capacity. Or, a drop in the price of gasoline may lead to a drop in the price of ethanol distillation equipment. The point being that an asset changes in value because the net present value of its expected services changes.

To clarify the difference between the reduction in service capacity and the total change in the value of an asset during a period, consider dividing this total change into two parts: reduced service capacity and price changes. This is most easily illustrated if use value and prices are measured in a single dimension so that there is no need for the multidimensional characteristic vector describing the asset. The simplest case is to measure the service capacity of the asset in terms of the number of available hours of potential use. If the market price of a unit of asset service at the beginning of the period is given by p_b, the beginning service potential (or remaining hours of potential use) by UV_b, and the ending service potential by UV_e, then the value of the amount of service reduction is given by

$$\begin{aligned} Cost\ of\ service\ reduction &= (p_b)\ (amount\ of\ service\ reduction) \\ &= (p_b)\ (UV_b - UV_e) . \end{aligned} \qquad \textbf{(6.1)}$$

The change in value due to price changes is called the price change cost and is given by

$$Price\ change\ cost = UV_e (p_b - p_e) \qquad \textbf{(6.2)}$$

where UV_e is the service potential at the end of the period and beginning and ending prices of the service potential are given by p_b and p_e, respectively. Total costs due to service reduction and price changes are given by the beginning of period value minus the ending value of the asset or

$$\begin{aligned} Service\ reduction\ cost + price\ change\ cost &= economic\ depreciation \\ &= ED \\ &= beginning\ value - ending\ value \\ &= V_0 - V_1 \end{aligned} \qquad \textbf{(6.3)}$$

where V_0 is value of the asset at the beginning of the period and V_1 is the value at the end of the period. The decline in the total market value of an asset in a particular year is thus a result of the physical and technical factors as well as the changes in the market price of a unit of the asset's service. This **total change in the total market value of an asset is economic depreciation** because it represents the decline in the value of the asset over the period.

For a farm or group of farms in which records are used as a source of data for cost estimates, economic depreciation (year-to-year declines in the estimated market value of the asset) can be used conceptually as an estimate of the service reduction and price change portion of ownership costs if such market value estimates can be obtained and inflationary impacts separated carefully. For a particular asset of a given age and condition, this approach could result in different estimates of physical and market depreciation depending upon the durable asset market in that year. For some assets, market values are difficult to secure. Also, assets such as buildings are attached to the land asset. Market value changes in such assets not only may be difficult to determine but also may not be reflective of their true economic worth to another user because of their immobility.

When beginning and ending values for a durable asset or its services are not easily available on a year-by-year basis, another method to estimate service reduction and price changes is needed. The most common method does not rely on annual market value changes, but estimates a constant annual cost assuming an expected rate of use and a salvage (remaining) value based on projected use and obsolescence. The most common assumption on the decline in remaining value per period is that it is constant over the life of the asset or constant per hour of use as with straight-line depreciation. This method is particularly useful for projected CAR estimates, but can also be useful in record-based estimates when the market values of assets are difficult to estimate. Year-to-year depreciation differences are not important in such cases because with most economic cost estimation techniques only an average year cost of depreciation is needed. This method is discussed in more detail in the subsection entitled Procedures for Cost Estimation.

Depreciation methods commonly used for tax purposes are not normally used in developing CAR estimates because they do not necessarily reflect the economic costs of owning and using an asset and are thus irrelevant to the economic costing process. Income tax impacts and their equivalent costing are also not included in this discussion. Tax shelter impacts on durable asset costs should be estimated through the use of capital budgeting for the assumed ownership period of the asset. Tax benefits can then be credited in the after tax flow of the costs. Once present values on an after-tax basis are estimated and amortized, they can be converted to an equivalent before-tax basis. These other forms of depreciation may be important to decision makers who are owners of durable assets for financial reasons but are not important for computing economic costs and returns. A more complete discussion of the tax impacts of durable ownership is contained in Watts and Helmers (1981) and Leatham and Baker.

An important assumption underlying the estimation of depreciation is a given estimate of annual use that exhausts the life of the asset over a specified period. This assumption of a given use per year exhausting an asset's life is sometimes forgotten, resulting in a concept of depreciation which is only age related. For purposes of economic costing as an average over an asset's life, the distinction of age and use causes of depreciation is not particularly important. Increased use of a durable asset in a year will reduce the life of the asset which, if remaining values are impacted only by use, will not impact depreciation cost per hour of use. Because remaining values depend on both age and use, however, it is important to insure that age and annual use assumptions are compatible with the salvage values used. In addition, opportunity costs per hour of use are reduced by greater use as will be seen in the next section.

Opportunity Costs

The second ownership cost associated with durable assets is the opportunity cost of the financial capital invested in the durable. This opportunity cost of ownership is often called **opportunity interest** because it is related to the interest rate available on financial capital. For depreciable assets, this opportunity interest cost is generally second to depreciation in magnitude. For record-based CAR estimates where an individual farm's cost is estimated for a particular set of assets with specific ages, interest costs should not be secured directly from paid interest because (1) an inflation-free interest cost is usually needed and (2) only a portion (or none) of the asset value is financed. Hence, for record-based data an opportunity cost on the market value of the asset should be used. For nonrecord-based estimates, opportunity interest cost is estimated on an average-year (or annuity) basis because year-to-year differences are unimportant to an annual average interest cost. Because the level of annual use impacts time of replacement, the assumption or determination of annual use is important to this costing process. The replacement time affects the length of time the asset is in use, and thus annual interest costs.

Market Value, Salvage Value, and Remaining Value

The market value of an asset is what it would sell for currently if placed on the market. The market value is determined by the service capacity of the asset and the value of that capacity to firms who utilize it in the production of other goods or services. The **salvage value** of an asset is the **market value that remains at the end of the costing period**. This salvage value will change based on the length of time the asset is held, its level of use, how well it is maintained, and changes in the market price of the asset’s services. The **remaining value** of an asset can be expressed as the **ratio of the current market price** of the asset in its current age and condition **to the initial purchase price of the asset**. This is often expressed as a percentage. The estimated values of aged farm machines are established at farm sales, at established machinery auctions, and by farm equipment dealers selling used equipment they have taken in trade. These market data are commonly summarized in “guides” and “bluebooks”. There are significant differences in remaining value for various makes and models of a given type of machine. When data on specific equipment or buildings are available, they can be used to estimate market value, salvage value, and remaining value. In most situations, specific data are not available, and other estimates must be used.

Data on actual purchase prices for new equipment frequently are not available except for specific transactions. The most frequently used proxy is the list price of the equipment as published in the *Official Guide* of the North American Equipment Dealers Association (NAEDA 1993, 1996). While this may overstate purchase price, it may not cause serious error if similar list prices are used to value used equipment. A common adjustment used by a number of universities for the difference between list price and purchase price is 15%, though this is a very rough number. Engineering estimates or dealer/contractor quotes are usually used as purchase prices for buildings, silos, fencing, tiles, and terracing. Some information on these prices may be available from real estate appraisal manuals such as *Agricultural Building Cost Guide* published by Boeckh, New Berlin, Wisconsin. An alternative is to use direct producer surveys.

Data on remaining values for equipment are most often obtained using estimates prepared by the American Society of Agricultural Engineers (ASAE D497.2 MAR94 in ASAE [1997]). A set of estimates used for many years gives the remaining values of four classes of equipment as a function of the years of use. The equations are reported in Table 6.1.

TABLE 6.1 Remaining Values as a Percent of List Price

Class of Equipment	Remaining Value as % of List Price at the End of Year n
Tractors	$68(0.920)^n$
All combines, cotton pickers, self-propelled windrowers	$64(0.885)^n$
Balers, forage harvesters, blowers, and self-propelled sprayers	$56(0.885)^n$
All other field machines	$60(0.885)^n$

Source: ASAE 1997.

These estimates were prepared initially by Wendall Bowers using data from the Spring 1965 issue of the *Official Guide* of the National Farm Power and Equipment Dealers Association. The estimated equations were modified by members of the machinery management committee of the ASAE in 1971; they have not been modified since. These estimates are based on adjustments to the declining balance method of computing depreciation to account for large first-year declines in value. The declining balance formula for remaining value is as follows

$$rv_n = (1 - \frac{rt}{life})^n \qquad \textbf{(6.4)}$$

where rv is the remaining value (expressed as a decimal), rt is the declining balance rate (1 for straight-line, 2 for double declining, etc.), and n is the number of years since purchase. The declining balance method assumes that the salvage value of the machine is included in the remaining value and never reaches 0. For example, if rt is 1.6 and the expected life is 20, the remaining value is $(0.92)^n$. This number is multiplied by the purchase price to get the value of the asset at a given point in time. Thus a machine with a purchase price of \$50,000 would have a value of \$32,954.076 $[(50{,}000)(.92)^5]$ after five years. The formulas in Table 6.1 adjust this declining value by a constant to reflect large first-year depreciation. For tractors this constant is 68. The numbers in Table 6.1 must be multiplied by 0.01 to obtain rv as a decimal. Based on a tractor with a purchase price of \$50,000, the remaining value after five years is \$22,408.77 $[(50{,}000)(68)(.92)^5(0.01)]$.

The estimates in Table 6.1 are based on data that are 30 years old. In addition to their age, these estimates have a number of problems related to markup values, geometric depreciation patterns, and constant reconditioning costs (Cross and Perry, 1995). Bowers (1992, 1994) has developed updates to these initial estimates based on more recent data but these updates have not been adopted by ASAE. The latest values as reported by Bowers (1994) are given in Table 6.2.

TABLE 6.2 Remaining Values as a Percent of List Price

Class of Equipment	Remaining Value as % of List Price at the End of Year n
Tractors	$67(0.940)^n$
Combines	$65(0.93)^n$
Cotton harvesters	$62(0.92)^n$
Windrowers, mowers	$67(0.90)^n$
Forage harvesters	$56(0.90)^n$
Balers	$66(0.92)^n$
Planters, tillage tools	$62(0.96)^n$

Source: Bowers 1994.

Recent papers by Cross and Perry (1995, 1996) estimate alternative remaining value functions based on auction sale prices reported in the *Farm Equipment Guide* published by Hot Line Inc. The data cover equipment manufactured from 1971 to 1993. Using a Box-Cox functional form they estimate remaining value as a function of age, use, care, manufacturer, auction type, region, national real net farm income, and the prime interest rate. Age and usage data as well as remaining value were transformed using the Box-Cox procedure while other variables were entered linearly. The estimation allowed for lags in the income variable. All prices were deflated using the Producer Price Index. Expressions suitable for use in cost estimation are reported in Table 6.3.

TABLE 6.3 Remaining Values as a Percent of List Price

Equipment Type	Remaining Value as % of List Price with Given AGE and Annual Hours of Use (AU)
Combines	$rv = [0.94534 - 0.04551\ AGE^{0.87} - 0.00182\ AU^{0.72}]^{2}$
Swathers	$rv = [0.94154 - 0.04564\ AGE^{0.5}]^{5.26}$
Balers	$rv = [0.95433 - 0.05939\ AGE^{0.57}]^{2.78}$
30-79 HP Tractors	$rv = [0.88507 - 0.05827\ AGE^{0.46} - 0.00018\ AU^{0.9}]^{2.17}$
80-149 HP Tractors	$rv = [0.97690 - 0.02301\ AGE^{0.76} - 0.0012\ AU^{0.6}]^{3.85}$
150+ HP Tractors	$rv = [1.18985 - 0.22231\ AGE^{0.35} - 0.00766\ AU^{0.39}]^{2.22}$
Planters	$rv = [0.80414 - 0.01939\ AGE^{0.89}]^{1.96}$
Plows	$rv = [0.61135 + 0.47309\ AGE^{-0.95}]^{1.61}$
Disks	$rv = [0.45198 + 0.60697\ AGE^{-0.85}]^{2.04}$
Manure spreaders	$rv = [1.29956 - 0.45113\ AGE^{0.25}]^{2.22}$
Skid steer loaders	$rv = 0.88302 - 0.2549\ AGE^{0.05} - 0.00002\ AU^{1.31}]^{1.96}$

Source: Cross and Perry, 1995.

The ASAE has adopted further reduced forms of the Cross and Perry (1995, 1996) equations beginning with the 1997 edition of the standards. These equations are reported in Table 6.4.

The Task Force recommends the set of equations in Table 6.4 be used for estimating remaining value.

All of these remaining value estimates are in real terms. Thus they represent the remaining value that a new item of equipment would have at a certain age assuming that equipment prices do not rise relative to the list price of the equipment. If an analysis is done in nominal terms, these estimates must be adjusted for inflation.

Salvage values for use in computing depreciation are usually determined using remaining value equations and an assumed economic life for the particular class of equipment. This salvage value is then used as the market value at the end of the assumed life. There are no firm guidelines for assumed years of use for different types of equipment. Common assumptions for tractors are between 10 and 20 years, whereas the assumed life for most other equipment other than plows and disks is usually shorter. The remaining value functions for plows and disks are very flat after about 10 years, although plows have lower annual depreciation.

TABLE 6.4 Remaining Values as a Percent of List Price

$$RV_n = 100[C_1 - C_2 (n^{0.5}) - C_3(AU^{0.5})]^2$$

RV_n remaining value at the end of n years of age
AU annual hours of use

Equipment Type	C_1	C_2	C_3
30-79 HP Tractors	0.9809	0.0934	0.0058
80-150 HP Tractors	0.9421	0.0997	0.0008
150 + HP Tractors	0.9756	0.1187	0.0019
Mowers	0.7557	0.0672	--------
Balers	0.8521	0.1014	--------
Combines	1.1318	0.1645	0.0079
Swathers	0.7911	0.0913	---------
Plows	0.7382	0.0510	--------
Disks	0.8906	0.1095	--------
Planters	0.8826	0.0778	--------
Manure spreaders	0.9427	0.1111	--------
Skid steer loaders	0.7858	0.0629	0.0033

Source: ASAE 1997.

Remaining values for buildings, silos, tile drains, fencing, and so forth are difficult to estimate in any general fashion because they are often specific to a particular operation. A common approach is to assume a fairly long useful life and a minimal salvage value.

Maintenance Costs

The **maintenance costs** of holding a durable asset are the expenses required to maintain the service potential of the asset at a reasonable level and to extract services for a single time period. Activities associated with these costs usually are not viewed as enhancing the service capacity of the capital asset in any significant way when determining its end-of-period value. Fuel, lubrication, and repairs are common examples of maintenance costs for durable equipment. If major repairs which extend the lifetime of the asset are projected when the asset is purchased, these should be included in the estimate of annual costs and an appropriate adjustment made to the salvage value. For record-based CAR estimates, such major repair expenses in a particular year can be a problem because there is inadequate knowledge over what period of time such costs should be allocated. Because costs such as fuel, lubrication, and repairs often involve the use of expendable inputs, hired services, or operator labor, it is common in computing the costs of owning and operating a piece of durable equipment not to include these costs in the section of the report on allocated overhead, but rather to include them in the operating costs section. As discussed in Chapter 2, Appendix 2C, and by Burt (1992) it makes some sense to combine all the costs of owning and operating the asset into one cost and income stream. This is particularly important in situations where the time patterns of economic depreciation and maintenance are variable.

Other (Time) Costs

Property taxes, storage or housing, and insurance are other costs attributable to the ownership of durable inputs. These costs are typically included in the allocated overhead portion of the estimates. As with maintenance, they can be combined with economic depreciation and opportunity interest to create a stream of total ownership and use costs over time.

ESTIMATING THE COSTS OF MACHINERY, BUILDINGS, AND EQUIPMENT

There are two general approaches to estimating ownership costs of durable assets. The first is to assume ownership of the asset by the producing firm. The second is to use the cost of leasing a durable asset as a measure of the ownership cost.

Estimating Costs Assuming Ownership

The two major ownership costs, economic depreciation (changes in service capacity and its price) and opportunity are often combined into a single annual cost using annuity formulas. The annualization process is a subset of equivalent capital budgeting approaches (Bierman and Smidt; Robison and Barry, 1996) for describing lifetime costs and/or returns (present value, future value, and amortized or annual value). Because the determination of economic costs involves only the estimate of an annual cost, year-to-year changes in asset market values, nominal interest costs, and debt retirement are not as important. These issues may be relevant to individual decision makers who are concerned with cash flow and balance sheet changes resulting from asset purchases, but they are not as critical for estimating CARs of individual enterprises.

Minor ownership costs may include property taxes, insurance and housing. They are usually estimated using observed tax and insurance rates and estimated asset values. Storage may affect asset condition, but asset condition does not impact the storage space required. The annual ownership cost for storage of an asset can be estimated as for other durables and costs allocated proportionately by space required.

As discussed earlier, record-based data are another source for estimating the depreciation portion of ownership costs using reported economic depreciation (year-to-year declines in market value). The difficulty is that few record keeping systems keep track of market as opposed to book values. This approach is more useful if the records contain accurate information on machine specifications, age, and use patterns so that data available from "guides" and "bluebooks" can be used to establish market value. Estimates from guides are most appropriate when there is an active local market reflecting frequent sales of machinery and equipment. Depreciation reported for income tax purposes should not be used for economic cost and return (CAR) estimation. Farm records are also a source of ownership costs relating to property taxes and insurance that are paid annually.

Lease and Custom Costs

A second general approach to the estimation of annual durable costs is to use lease and custom charges, either as a substitute for the above ownership cost approach or where lease or custom use is common. A lease or custom charge for a durable input embodies the above-described depreciation factors (age, use, and obsolescence), interest on invested capital, and other ownership costs. Custom charges may also, however, include inputs such as labor, which must be separated from the custom charge to isolate the cost of the durable service. This is particularly important when some labor associated with the machine operation is performed by the farm operator and some by the custom operator. Leasing costs are likely to be based on hours or acres of use. These costs per hour can be directly translated to an annual enterprise cost through the assumption of a particular usage per year. However, constructing CAR estimates using leasing charges requires good knowledge of the hours used by each enterprise. In addition, for producers who are large enough to take advantage of economies of scale in the use of durable equipment, the cost of leasing may be higher than the cost of owning and operating the same equipment. For example, a large-scale hog operation may be able to justify the cost of its own trucking fleet with lower costs than leasing the same tractors and trailers. In other areas there may be a short-run excess supply of custom operators due to other producers who perform custom work on the side to increase income and spread overhead costs when excess machine time is available. In these situations, the cost of leasing may be less than the cost of ownership, but only for short periods. The availability of custom operators may also be a legitimate concern. If most of these are other producers who perform custom operations during slack periods, there may be problems in getting operations performed in a timely manner. The bottom line is that cost of production estimates should reflect the cost of providing the needed service (appropriate quality and timeliness) at the minimum cost over a long-run time period.

> ***The Task Force recommends that where an active market for the leasing of assets exists and there is good knowledge of the use of a leased asset by enterprise, and there are no particular benefits to asset ownership, the ownership costs derived from leasing rates be the primary approach to estimating costs.***

CAPITAL ASSETS AND NATURE OF THE ESTIMATES

Projected and historical CARs sometimes are constructed utilizing cost records of one or several farms using the specific durable assets existing on those farms. There are two approaches to find the cost of using those durable assets. The first is to use market values of the specific durable assets on that farm or groups of farms in the estimation of ownership costs. This approach has the advantage of representing "actual" or current costs incurred in production, but it has the potential disadvantage of not representing durable asset costs adequately in a longer-run perspective. For example, durable assets used in the production of a low profit or minor enterprise may have low current market value, but a higher use and replacement value. The use of this low market value may result in a uniquely low cost of durable assets for that enterprise. Using a group of farms, one might expect that across those farms there would be a range in the ages of their durable assets used for this type of enterprise. However, for small or low-profit enterprises, a major proportion of a group of farms may be using durable assets that have been largely depreciated. An example of this is a small livestock enterprise using heavily depreciated buildings and equipment.

Because of these problems, a second approach when using farm records is to utilize the type and size information on durable assets secured from records, but to estimate costs based on replacement costs of those assets. This is a better approach in estimating long-run costs; however, it still has a disadvantage. It may well be that a farmer or group of farmers are utilizing older depreciated equipment of a particular size for a specific enterprise which would not be the case if those farmers were to plan asset purchases and enterprise mixes in a "fresh" or longer-run sense. Thus, data from farm records on specific assets may involve serious suboptimal assumptions for minor enterprises. A third alternative would be to assume that farmers continually replace old equipment with used equipment of a similar type. This may reflect more accurately the age composition of equipment on farms but may not be feasible given limited information on market prices of used equipment.

Cost and return estimates developed in a synthetic manner, in which a determination of the appropriate durable asset mix is made, attempt to resolve some of the above problems. However, assumptions regarding durable asset mixes to be used in the production of an enterprise can be faulty unless very carefully determined. In particular, when CAR estimates are specified involving either a single enterprise or enterprise mixes it is important that the mix of durable assets be optimized before attempting cost analysis. Quite often CARs estimated in this synthetic manner focus on only one enterprise; however, when farms are involved in two or more enterprises, the lack of asset optimization can reduce the applicability of the estimates. Optimization can either be carried out formally using mathematical programming for multiple time periods, or simply approximated using partial budgeting and several tractor and machine combinations.

The Task Force recommends that when CAR estimates are constructed synthetically using durable asset complements, this durable set be optimized for the assumed enterprise size.

The question often arises, particularly when preparing historical estimates, whether to use the market price of a new asset with a new expected life or the market price of a used asset, similar to the age of those typically traded on the market, with an expected life based on the used purchase and prior use. To the extent that the annualized total cost per hour of use (including maintenance) may be different for a new and a used machine, the choice is not immaterial. This may be particularly important if the new and used machinery markets are in disequilibrium. Over a long time period, these differences should even out given tendency of new and used markets to settle into an equilibrium pattern. In the shorter run, however, estimates for a producer who is using mostly used equipment may be more accurate using purchase prices for new as compared to used equipment. The repair cost equations in Chapter 5 and the remaining value equations in this chapter are based on list prices. Thus, list prices for new equipment must be used for these computations. Once the salvage value for a new machine that will be the appropriate number of years old when the current used machine is to be sold has been determined, the current market price and expected remaining age can be used to determine the capital costs of the used machine. And as discussed in Chapter 5, an annual repair cost for this used machine can also be determined. The Task Force suggests that most CAR estimates be developed using prices for new equipment given that better data is usually available for these machines. In situations where the new and used markets are clearly out of equilibrium or in cases where a producer has a unique set of used machines, the Task Force encourages the use of data that best represents the situation at hand, whether new or used.

The Task Force generally recommends using the price, expected age, and expected salvage value for new equipment in computing capital service costs. In situations where the new and used markets are not in equilibrium and market prices for used equipment are used as appropriate, the Task Force encourages the preparer to include a detailed description of the assumptions made and the calculations used.

ENTERPRISE SIZE AND DURABLE ASSETS

For relatively small enterprises, the use of budgeted ownership costs for durable assets should be seriously questioned because such enterprises may not fully utilize purchased durable equipment. For these situations, the preferred approach is to estimate costs assuming the leasing of durable assets as opposed to the determination of depreciation, opportunity cost, repairs, property tax, and housing costs. In some farming situations, custom operations are also common, and this should be considered carefully as an alternative to estimating ownership costs of those durable assets for small farms and enterprises, particularly when the costs of leasing and custom use are less than ownership.

The Task Force recommends that when CAR estimates are constructed for relatively small enterprises or for assets that are infrequently used, leasing costs as opposed to estimation of ownership costs for those assets should be used.

TIME POINT AND INFLATION

The issue of inflation has particular relevance to the estimation of durable costs. If only annual inputs were used in the production of agricultural commodities, inflation would be of far less importance to the costing process. Because durables involve multiperiods, inflation has an impact on interest rates, asset values, and returns.

In a capital budgeting analysis of investments, it is obvious that a specific time point is required. Also, in economic feasibility analysis of durable inputs, it is well understood that time points are important in the discounting analysis, not only to the return flow but the cost flow. In CAR estimation, which is a subset of capital budgeting, the CAR estimate must be constructed explicitly in reference to a time point. Returns and costs must all be adjusted to the same time point. The issue of appropriate time points for evaluating CARs is complicated further by the consideration of inflation. Thus, these two conditions (inflation and no inflation) are discussed separately.

No Inflation

Under conditions of no inflation and linear depreciation, annual durable cost estimates are constant across the asset's life. These estimates are usually expressed on an end-of-year basis. This is because the typical depreciation and opportunity cost estimation process implies an end-of-year time reference cost point. With no inflation, the nominal interest/discount rate is identical to the real discount rate.

Inflation

With respect to the costing of durable inputs, inflation impacts new asset values, remaining values, salvage values, and interest rates, as well as the return flow. A nominal cost analysis using nominal interest rates and nominal salvage values for assets, which is then placed in a CAR framework, is an alternative to the use of real interest rates and real salvage values. However, there are a number of limitations to the use of nominal CAR expressions. These limitations include (1) specifying the expected inflation rate and (2) a specified time period for the analysis. This specified time period is necessary so that (a) the nominal cost expressions can be discounted and reamortized to a constant nominal expression and (b) inflation-impacted returns can also be discounted and reamortized to a constant nominal expression. The latter issue is essential to any proper comparison of costs to returns. By removing inflation and using real interest rates, these complexities are reduced significantly.

The use of nominal interest costs and nominal salvage values results in a cost expression (end-of-year) which is constant over the asset's life. This expression can be termed a constant nominal expression with declining real value. For comparability, the corresponding returns also increase nominally over the time period due to inflation. This increasing nominal return flow must be placed on the same constant nominal flow basis as the nominal costing implies. Thus, the increasing nominal return expression must be discounted to a present value and then be amortized at a nominal discount rate for comparability. This requires the explicit use of a finite time period of analysis. In addition, the construction of an increasing nominal return flow requires the assumption of a particular rate of inflation. For these reasons a real CAR budget is preferable to a nominal budget.

A real costing process under inflationary conditions involves the use of real interest rates and a real salvage value and results in the same process as that under no inflation. This process is considerably less complex than the process of forming constant nominal return expressions. It assumes returns in the long run increase with inflation and does not require a specific estimate of inflation. Of course, if there is reason to believe or evidence to suggest a shift in the expected return flows, the real return can be so adjusted.

The Task Force recommends that all CAR estimates have an explicit time point.

The Task Force recommends that CAR estimates use a real interest/discount rate for adjusting CAR flows between years (over time) as when computing opportunity interest cost or capital recovery factors for durable assets.

PROCEDURES FOR COST ESTIMATION

Economic depreciation and opportunity cost can be estimated in two general ways. One is the splitting of the two as an approximation. This procedure can be termed as traditional, and results in

$$D = \frac{V_0 - V_n}{n} = \frac{PP - SV}{n} \tag{6.5}$$

$$OC = \left(\frac{V_0 + V_n + D}{2}\right)(r) = \left(\frac{PP + SV + D}{2}\right)(r) \tag{6.6}$$

where

V_0 = Value of asset at the beginning of period 1 (end of period 0)
V_n = Value of asset at the end of period n
D = Straight-line economic depreciation occurring during each period
PP = Purchase price of asset at beginning of the first period
SV = Salvage value of asset at end of period n
OC = Opportunity interest cost
r = real interest rate
n = time period in years.

It is assumed that all values are in real terms. V_0 is generally the purchase price of a new piece of equipment and V_n is almost always estimated based on the list price of new equipment. Equation 6.6 is slightly different from the formula often seen in farm management textbooks and extension publications. In Equation 6.6, depreciation is included in the numerator rather than taking a simple average of purchase and salvage values. This is because the opportunity interest cost is computed on the value of the investment at the beginning of the year because the asset is held for the entire year. For clarification, compare equations 6.5 and 6.6 with a one-year time horizon to equation 2.20 assuming a real interest rate and no inflation. Equation 2.20 gives the opportunity cost at the end of the year of holding the asset for one year. Equation 2.20 with no inflation is

$$\begin{aligned} OC &= V_0 \, i \\ &= V_0 (\pi + r + \pi r) \\ &= V_0 (0 + r + 0 r) \\ &= V_0 \, r \end{aligned} \tag{2.20}$$

where i is the nominal interest rate, π is the rate of inflation, and r is the real interest rate. Rewriting equations 6.5 and 6.6 assuming a one year time horizon gives

$$\begin{aligned} D &= \frac{V_0 - V_1}{1} \\ &= V_0 - V_1 \end{aligned}$$

$$\begin{aligned} OC &= \left(\frac{V_0 + V_1 + D}{2} \right) (r) \\ &= \left(\frac{V_0 + V_1 + (V_0 - V_n)}{2} \right) (r) \\ &= \left(\frac{2 V_0}{2} \right) (r) = V_0 \, r \, . \end{aligned}$$

Depreciation is removed if a midyear value for the opportunity cost is desired. Including depreciation in the equation makes this method perform more closely to the exact capital recovery (annuity) method discussed later, and corrects for the inherent negative bias present if D is excluded (Walrath; Kay). As the length of each time period decreases, the importance of D also decreases with it disappearing in the limit.

Watts and Helmers (1979) have discussed further the reasons for adding D to equation 6.6 rather than eliminating it to get a midyear asset value. A simple example demonstrates this point. Suppose an asset with zero salvage value costs $100,000 originally and has a life of five years. Straight-line depreciation is $20,000 per year. Opportunity interest cost (per year) is usually perceived to be charged on the beginning-of-year asset value. In this case, the values are $100,000, $80,000, $60,000, $40,000, and $20,000, respectively. Using a 4% real interest rate results in opportunity interest costs of $4,000, $3,200, $2,400, $1,600, and $800, respectively, or a simple average of $2,400. The use of equations 6.5 and 6.6 gives the same result as follows

$$D = \frac{100,000}{5} = 20,000$$

$$OC = \left(\frac{100,000 + 0 + 20,000}{2} \right)(.04) = 2,400 .$$

Removing D results in an opportunity cost estimate of \$2,000 [(100,000/2)(.04)]. This implicitly requires interest charges to be charged on the midyear values of \$90,000, \$70,000, \$50,000, \$30,000 and \$10,000, or \$3,600, \$2,800, \$2,000, \$1,200 and \$400, to give the average of \$2,000.

The second and exact method (sometimes termed capital recovery or an annuity cost) is the annualizing of the two components (economic depreciation and opportunity cost) together. This method is presented as Equation 6.7. Equation 6.7 is identical to the capital budgeting approach where original cost less the present value of the salvage value is amortized over its life. It is also the same as equation 2.31 where V_n is in real terms and CSC is the capital service cost expressed as an annuity.

$$CSC = \frac{\left(V_0 - \frac{V_n}{(1+r)^n} \right)}{\left(\frac{1 - \frac{1}{(1+r)^n}}{r} \right)} = \frac{\left(PP - \frac{SV}{(1+r)^n} \right)}{\left(\frac{1 - \frac{1}{(1+r)^n}}{r} \right)} . \qquad \textbf{(6.7)}$$

The denominator in equation 6.7 is a uniform series (US_0) with interest rate r and period n as defined in equation 2B.8. Thus, CSC can be computed using the standard annuity functions available on business calculators or in spreadsheet programs (such as PMT in EXCEL). For such canned procedures $\left(V_0 - \frac{V_n}{(1+r)^n} \right)$ is used as the present value of the annuity with the assumption that the payment is made at the end of the period. Equation 6.7 can also be written in an alternative fashion as follows

$$CSC = \frac{(PP - SV)}{\left(\frac{1 - \frac{1}{(1+r)^n}}{r}\right)} + SV(r) \qquad \textbf{(6.8)}$$

$$= \frac{(PP - SV)r}{1 - (1+r)^{-n}} + SV(r).$$

The steps in going from 6.7 to 6.8 are contained in Appendix 6B. The appropriate forms for a nominal annuity are also contained in this appendix. The capital recovery method gives a constant annual payment that has the same present value as the economic cost of holding the asset for n periods computed using the methods discussed in Chapter 2. This method accounts for costs due to service reduction, changes in market price, and the opportunity cost associated with the financial capital tied up in the asset.

These two methods (traditional and capital recovery) typically use a new cost and expected salvage value without concern about the nature of the remaining value function (depreciation) over the asset life. This is because the costing process is only concerned with the average cost over the lifetime of the asset, not individual years. Even if V_0 is for a purchased used asset, once V_n is determined, the analysis assumes straight-line depreciation over the remaining life and an average cost over this period is obtained. The expected salvage value assumes no change in the asset value due to inflation because this is a real analysis. Adjusted formulas using nominal interest rates are discussed in the example below.

The capital recovery approach is well-suited to the inclusion of maintenance and other time costs in the construction of an annual capital service cost, while the traditional method is not. Rather than using $\left(V_0 - \frac{V_n}{(1+r)^n}\right)$ (which represents only the discounted value of the change in market value over the asset's life) in the numerator of equation 6.7, the present value of the entire cost/income stream associated with the asset can be used in computing an annual annuity payment associated with the durable asset. An example of this procedure is contained in Appendix 2C.

EXAMPLE COST CALCULATION FOR A DURABLE ASSET

A simple example under no inflation and inflation situations is presented here. It assumes an asset with a purchase price (PP) of $105,000, a useful life (n) of five years at 400 hours per year, and a salvage value (SV) of $5,000 (real or noninflated dollars). It is assumed that maintenance and other time costs are accounted for elsewhere. The total cost per year, as well as per hour, is estimated. This can be further allocated on a per acre or per bushel basis. A higher use of the asset per year (say 500 hours) would reduce its expected life to four years if it is assumed that the asset has 2,000 hours of life. In such a case the interest portion of the ownership cost per hour of use changes.

Costs with No Inflation

Assume a 4% real interest/discount rate. The traditional cost method is computed in two parts as follows

$$
\begin{aligned}
D &= \frac{PP - SV}{n} \\
&= \frac{(105{,}000 - 5{,}000)}{5} = 20{,}000 \\
OC &= \left(\frac{PP + SV + D}{2}\right)(r) \\
&= \left(\frac{105{,}000 + 5{,}000 + 20{,}000}{2}\right)(.04) = 2{,}600.
\end{aligned}
\tag{6.9}
$$

The traditional method thus results in a cost of $20,000 per year or $50 per hour for economic depreciation and $2,600 per year or $6.50 per hour for opportunity cost, for a total annual cost of $22,600 ($56.50 per hour). The capital recovery cost is computed using equation 6.7 as follows

$$
\begin{aligned}
CSC &= \frac{\left(PP - \dfrac{SV}{(1+r)^n}\right)}{\left(\dfrac{1 - \dfrac{1}{(1+r)^n}}{r}\right)} \\
&= \frac{\left(105{,}000 - \dfrac{5{,}000}{(1.04)^5}\right)}{\left(\dfrac{1 - \dfrac{1}{(1.04)^5}}{.04}\right)} \\
&= \frac{105{,}000 - \dfrac{5{,}000}{1.21665}}{4.451822} \\
&= \frac{105{,}000 - 4{,}109.6355}{4.451822} \\
&= \frac{100{,}890.364}{4.451822} \\
&= 22{,}662.711.
\end{aligned}
\tag{6.10}
$$

The annual cost using this method is thus $22,662.71 ($56.66 per hour). Both are end-of-year estimates. A return flow of $22,662.71 per year (received at end of each year) would then exactly exhaust the initial cost of the machine.

Inflation

If we assume a 4% real interest rate, the same as for the no inflation scenario, and a 5% inflation rate, the implied nominal rate is 9.2%. One way to introduce inflation is to adjust the real values computed in equation 6.10. The real cost estimate is $22,662.71 or $56.66 per hour as before. A real annual return of $22,662.71 would exactly exhaust the machine cost. The value of this cost stream at the end of the first year is $23,795.85 [($22,662.71)(1.05)]. The equivalent nominal values at the end of years two to five are $24,985.64, $26,234.92, $27,546.67, and $28,924 respectively, where each return rises at the rate of inflation. If the CAR analysis for a single year is done in nominal terms at the end of the year as suggested by this Task Force, then the appropriate annual cost for this asset is $23,795.85 (the end of first year value). As mentioned in Chapter 2, the Task Force recommends that analysis for years other than the current one be done in real terms. This implies that the price of the machine increases by 5% during the first year, but remains at this real value for future years. Similar assumptions must be made about each asset and return stream included in the CAR estimate.

An alternative approach to introduce inflation is to make the computation in nominal terms using nominal interest rates and nominal salvage values. With 5% inflation per year the projected salvage value is $6,381.41 [$(5,000)(1.05)^5$]. For the traditional method, the nominal costs are given by

$$D = \frac{(105{,}000 - 6{,}381.41)}{5} = 19{,}723.72$$

$$OC = \left(\frac{105{,}000 + 6{,}381.41 + 19{,}723.72}{2}\right)(.092) = 6{,}030.84 \qquad \textbf{(6.11)}$$

which gives total nominal costs of $25,754.56 ($64.39 per hour). The capital recovery (annuity) method is computed using the nominal version of equation 6.7, a nominal interest rate of 9.2%, and the nominal salvage value as follows

$$CSC = \frac{\left(105{,}000 - \frac{6{,}381.408}{(1.092)^5}\right)}{\left(\frac{1 - \frac{1}{(1.092)^5}}{.092}\right)} = \frac{100{,}890.364}{3.86955} = 26{,}072.89. \tag{6.12}$$

Making the computations in nominal values results in a cost of $26,072.89 which is equivalent to $65.18 per hour in constant nominal dollars. The problem with using this cost as opposed to the $23,795.84 computed previously is that this nominal annuity assumes that inflation will continue at 5% over the life of the asset. A similar assumption would need to be made for other assets, each with its own useful life and potentially different inflation values, as well as for future returns. Thus the real annuity adjusted to the end of the year using the annual inflation rate resulting in a cost of $23,795.84 is the preferred method.

The inflated real and nominal streams have the same present value. This can be seen by computing the value of each stream at the end of the first year assuming a nominal interest rate of 9.2%. This gives

$$\begin{aligned} V_1^r &= 23{,}795.85 + \frac{24{,}985.64}{(1.092)} + \frac{26{,}234.92}{(1.092)^2} + \frac{27{,}546.67}{(1.092)^3} + \frac{28{,}924}{(1.092)^4} \\ &= 11{,}0172.28 \\ V_1^n &= 26{,}072.89 + \frac{26{,}072.89}{(1.092)} + \frac{26{,}072.89}{(1.092)^2} + \frac{26{,}072.89}{(1.092)^3} + \frac{26{,}072.89}{(1.092)^4} \\ &= 11{,}0172.28 \end{aligned} \tag{6.13}$$

where V_1^r and V_1^n denote the value at the end of period one of the inflated real and constant nominal streams, respectively.

A table similar to Table 2.12 for this example is presented in Table 6.5 for easy reference and comparison. This table uses equation 2.28 to compute the capital service cost as the sum of the opportunity cost and the combined cost of service reduction and the changes in price. The equation is repeated here for convenience. The table also divides up opportunity interest into inflation and real interest components following the procedures in Appendix 2A.

$$\begin{aligned} \text{Capital service cost } (CSC) &\approx \text{Opportunity cost} + \text{service reduction cost} + \text{change in price} \\ &= \text{Opportunity cost} + (V_0 - V_1) \\ &= iV_0 + (V_0 - V_1)\,. \end{aligned} \tag{2.28}$$

Annual straight-line depreciation in real terms is $20,000 per year. With inflation, this gives a nominal stream equal to [21,000, 22,050, 23,152.5, 24,310.125, 25,525.631]. The ending (salvage) value of the asset in nominal terms is $6,381.41. Notice that the opportunity cost (reported in the investment row) falls over time from $9,660 to $2,795.66 while the costs due to changes in value rise from $15,750 to $24,006.25 due to increases in the price level. This last category would be constant at $20,000 if there were no inflation.

If one were to assume that depreciation followed a sum-of-the-years pattern for five years the depreciation factors would be (.3333, .2667, .20, .1333, .0667) with annual real depreciation of $33,333, $26,667, $20,000, $13,333, and $6,667. Table 6.6 presents the same information as Table 6.5 but for this case. Notice that present value of total costs and the real and nominal annuities do not change. Thus the choice of straight-line or sum-of-the-years for depreciation in use value has no impact on the cost analysis. It will, however, affect the estimated market value of the asset during the period the asset is held. The lower charges for opportunity interest costs in early years are compensated for by higher charges for service reduction and changes in price.

If an asset is used more heavily during a given year so that its useful life (in years) is less, the costs of ownership and use will change. For the above example, with 500 hours of use per year, the asset life is only four years. This would result in an annual real cost of $27,749.00 ($55.50 per hour) using the capital recovery method and an annual real cost of $27,700 ($55.40 per hour) for the traditional method. Similarly, using a nominal analysis the capital recovery cost per year is $31,227.55 ($62.46 per hour) whereas the traditional method results in an annual cost of $30,977.79 ($61.96 per hour). It is well recognized that age and actual obsolescence impact the cost of depreciable assets. However, in CAR estimates, developing depreciation and interest costs on a per hour of use basis using expected annual use and expected obsolescence is the preferred approach.

A nominal analysis becomes impractical in most CAR estimates because of the various asset lives of durables in firms. A consistent nominal analysis involving a changing dollar value requires the return side to have the same time period of analysis as the cost side. Yet farms have durables with various asset lives. This is complicated further by land ownership because land is an infinitely lived asset. Thus, a proper nominal analysis would require enormous capital budgeting adjustments to reach meaningful CAR expressions.

The Task Force recommends the capital recovery (annuity) method of calculating annual depreciation and interest costs over the traditional method.

The Task Force recommends that the capital recovery method of calculating annual depreciation and interest costs use a real interest rate for computation and then inflate this cost to the end of the first year using the annual rate of inflation.

The Task Force recommends that because annual asset use affects the replacement interval and therefore depreciation and opportunity interest costs, these costs should be constructed on a per hour of use basis for inclusion in cost and return estimates.

Given that some decline in use value may occur due to time and obsolescence in addition to machine use, the Task Force recommends that careful consideration be given in choosing the useful life of equipment and machinery so that older machines with low hours of use do not have their use value overstated.

Other Costs

Normally, estimates of property taxes and insurance are based on tax and insurance rates multiplied by the asset midvalue. For economic costing only an average value over the asset's lifetime is of interest. This is given by an average of the initial and salvage values. Insurance rates and property tax rates vary by state and by asset type. Appropriate housing may not increase an asset's life but it may increase its salvage value (Hunt, 1995: 71). Data on housing costs like that on taxes and insurance vary widely from farm to farm and state to state. When data are not available, the ASAE (ASAE EP496.2 MAR94 in ASAE [1997]) recommends percentages of the purchase price of the asset as presented in Table 6.7. When a purchase price is not available, a list price or some percentage of it may be used as a proxy. These costs are then added to the other annual costs of use for the durable asset.

JOINT COSTS AND OPTIMAL INPUT COMPLEMENTS

As mentioned in the introduction to this chapter, multiple enterprise use of durable inputs is common in agriculture. Most farms produce more than one product. When this occurs, durable factors of production as well as other inputs may be shared among enterprises. In some situations, two enterprises may share the use of a particular durable input, while other enterprises on the farm may not. This would be the case for a farm where the crop enterprises use all the tractors and crop land, while the livestock enterprises only use some of the tractors and a small proportion of the land.

The issue of joint costs and joint returns and their allocation in multiple product farms/firms has been long known to involve major conceptual problems. This can also extend to single product farms/firms in which it is desired to assign joint costs to alternative production methods or different forms of production. The theoretical severity of problems in decision making resulting from the arbitrary allocation of joint costs to the respective joint-use outputs is unknown particularly when one CAR statement is used to reflect enterprise cost on different sized farms, and varying output mixes for a given farm size. The result is that under joint-use conditions, when costs of shared durable inputs and labor are arbitrarily assigned to individual enterprises, it is not clear that this is a close approximation to the true input costs attributable to each enterprise. This topic is discussed in more detail in Chapter 9: Joint Costs, General Farm Overhead, and Rights to Produce. Thus in making an allocation of costs to enterprises great care should be taken.

For any static output mix there is an optimal set of durable factors of production. The determination of that set for a particular output system can be secured from farm records or a similar collection of historical data, or in the case of projected CAR estimates a solution can be obtained from engineering estimates, linear programming, capital budgeting techniques, machine optimization programs, and so forth. Useful references on the optimal choice of capital equipment include Reid and Bradford; Perry et al.; Robison and Barry (1996: Chapter 15); Perry and Nixon; Weersink and Stauber; Leatham and Baker; and Bowers (1994). If the purpose of the CAR measurement is enterprise decision making given a specific set of fixed factors, then allocation of these costs across enterprises should be discouraged. If the analysis is long run in nature, then allocation of these costs to a particular output is important. Similarly, if the purpose of the CAR measurement is policy analysis requiring an estimate of the total costs of production, assignment of joint costs is required. In such cases, the intensity of use of any durable input by a product would appear to be the assignment mechanism. For example, the cost of a tractor used by various crop enterprises should not have its cost apportioned by simple hours of use, but the load requirements should be factored in as well.

> ***The Task Force recommends that where CAR estimates are developed for purposes of comparing the profitability of enterprises, costs of fixed assets common to two or more of these enterprises remain unallocated except when required for a specific purpose.***

TABLE 6.5 Annual Costs of Using Asset ($105,000 Purchase Price) over a 5-year Period Assuming Equal Annual Depreciation

Annual real interest	4%
Annual inflation rate	5%
Annual nominal interest	9.2%
Original value of asset	$105,000
Depreciation over 5-year time period	$100,000
Salvage value of asset	$5,000
Life in years	5
Annual straight-line depreciation in $	$20,000
Annual use in hours	400
Ending Value $(1+\pi)V_0$ - D	

Capital service cost (CSC) $= iV_0 + (V_0 - V_1)$

	Total	**Per Hour**
Nominal Annuity for Capital Service Cost (CSC N)	26,072.893	65.182232
Real Annuity for Capital Service Cost (CSC R)	22,662.711	56.656778

Year	Item	Beginning Value	Opportunity Cost	Inflation Cost	Real Interest Cost	Real Depr.	Nominal Depr.	Ending Value	Total Cost
1	Investment Cost (iV_0)	105,000	9,660	5,250	4,410	20,000	21,000	89,250	9,660
	Service reduction + Change in price $(V_0 - V_1)$								15,750
	Total Annual Cost (CSC)								25,410
	CSC N								26,072.893
	CSC R with inflation adjustment								23,795.847
2	Investment Cost (iV_0)	89,250	8,211	4,462.5	3,748.5	20,000	22,050	71,662.5	8,211
	Service reduction + Change in price $(V_0 - V_1)$								17,587.5
	Total Annual Cost (CSC)								25,798.5
	CSC N								26,072.893
	CSC R with inflation adjustment								24,985.639

TABLE 6.5 (continued)

Year	Item	Beginning Value	Opportunity Cost	Inflation Cost	Real Interest Cost	Real Depr.	Nominal Depr.	Ending Value	Total Cost
3	Investment Cost (iV_0)	71,662.5	6,592.95	3,583.125	3,009.825	20,000	23,152.5	52,093.125	6,592.95
	Service reduction + Change in price (V_0 - V_1)								19,569.375
	Total Annual Cost (CSC)								26,162.325
	CSC N								26,072.893
	CSC R with inflation adjustment								26,234.921
4	Investment Cost (iV_0)	52,093.125	4,792.5675	2,604.656	2,187.9113	20,000	24,310.125	30,387.656	4,792.5675
	Service reduction + Change in price (V_0 - V_1)								21,705.469
	Total Annual Cost (CSC)								26,498.036
	CSC N								26,072.893
	CSC R with inflation adjustment								27,546.667
5	Investment Cost (iV_0)	30,387.656	2,795.6644	1,519.382	1,276.2816	20,000	25,525.631	6,381.4078	2,795.6644
	Service reduction + Change in price (V_0 - V_1)								24,006.248
	Total Annual Cost (CSC)								26,801.913
	CSC N								26,072.893
	CSC R with inflation adjustment								28,924.001
	Total cost over entire period								130,670.77
	Average cost								26,134.155
	US_0 (.04, 5)	4.4518223							
	US_0 (.092, 5)	3.8695501							
	P.V. of annual costs at end of period 1								110,172.28
	P.V. of annual costs at beginning of period 1								100,890.36
	P.V. of nominal annuity (CSC N) at end of period 1								110,172.28
	P.V. of inflating real annuity (CSC R) at end of period 1								110,172.28

TABLE 6.6 Annual Costs of Using Asset ($105,000 Purchase Price) over a 5-year Period Assuming Sum-of-the-years Depreciation

Annual real interest	4%
Annual inflation rate	5%
Annual nominal interest	9.2%
Original value of asset	$105,000
Depreciation over 5-year time period	$100,000
Salvage value of asset	$5,000
Life in years	5
Annual use in hours	400
Ending Value $(1+\pi)V_0$ - D	

Year	Depreciation
1	33,333.33
2	28,666.66
3	20,000
4	13,333.33
5	466.66

Capital service cost (CSC) = $iV_0 + (V_0 - V_1)$

	Total	**Per Hour**
Nominal Capital Service Cost (CSC N)	26,072.893	65.182232
Real Capital Service Cost (CSC R)	22,662.711	56.656778

Year	Item	Beginning Value	Opportunity Cost	Inflation Cost	Real Interest Cost	Real Depr.	Nominal Depr.	Ending Value	Total Cost
1	Investment Cost (iV_0)	105,000	9,660	5,250	4,410	33,333.33	35,000	75,250	9,660
	Service reduction + Change in price (V_0 - V_1)								29,750
	Total Annual Cost (CSC)								39,410
	CSC N								26,072.893
	CSC R with inflation adjustment								23,795.847
2	Investment Cost (iV_0)	752,500	6,923	3,762.5	3,160.5	26,666.66	29,400	49,612.5	6,923
	Service reduction + Change in price (V_0 - V_1)								25,637.5
	Total Annual Cost (CSC)								32,560.5
	CSC N								26,072.893
	CSC R with inflation adjustment								24,985.639

Year	TABLE 6.6 (continued) Item	Beginning Value	Opportunity Cost	Inflation Cost	Real Interest Cost	Real Depr.	Nominal Depr.	Ending Value	Total Cost
3	Investment Cost (iV_0)	49,612.55	4,564.35	2,480.63	2,083.725	20,000	23,152.5	28,940.63	4,564.35
	Service reduction + Change in price (V_0 - V_1)								20,671.875
	Total Annual Cost (CSC)								25,236.225
	CSC N								26,072.893
	CSC R with inflation adjustment								26,234.921
4	Investment Cost (iV_0)	28,940.625	2,662.54	1,447.03	1,215.506	13,333.33	16,206.75	14,180.91	2,662.5375
	Service reduction + Change in price (V_0 - V_1)								14,759.719
	Total Annual Cost (CSC)								17,442.256
	CSC N								26,072.893
	CSC R with inflation adjustment								27,546.667
5	Investment Cost (iV_0)	14,180.906	1,304.64	709.045	595.598	666.666	8,508.5438	6,381.4078	1,304.6434
	Service reduction + Change in price (V_0 - V_1)								7,799.4984
	Total Annual Cost (CSC)								9,104.1481
	CSC N								26,072.893
	CSC R with inflation adjustment								28,924.001
	Total cost over entire period								123,733.23
	Average cost								24,746.624
	US_0 (.04, 5)	4.4518223							
	US_0 (.092, 5)	3.8695501							
	P.V. of annual costs at end of period 1								110,172.28
	P.V. of annual costs at beginning of period 1								100,890.36
	P.V. of nominal annuity (CSC N) at end of period 1								110,172.28
	P.V. of inflating real annuity (CSC R) at end of period 1								110,172.28

TABLE 6.7 Annual Costs of Taxes, Housing, and Insurance as a Percentage of Purchase Price

Annual Cost Item	% of Purchase Price
Taxes	1.00
Housing	.75
Insurance	.25
Total	2.00

APPENDIX 6A

Combining Ownership and Use Costs for Durable Assets with Variable Productivity

As discussed in the section of Chapter 2 entitled Defining Factors of Production and Products, cost of production studies typically assume constant productivity across time for most inputs including machinery, equipment, and buildings. The justification for constant productivity of machinery is that appropriate and increasing repair expenditures can maintain service capacity at an undiminished rate. The assumption of variable productivity is often more reasonable in the case of breeding livestock, perennial crops, some types of wells, and some land or range resources. Furthermore, it may also be appropriate to compute machinery costs assuming a variable rate of productivity over time. This appendix considers a method called the unit cost theory of depreciation originally developed by J. S. Taylor and refined by Harold Hotelling which computes a cost of ownership *and use* based not on units of the asset but on units of output produced by the asset[1]. By considering the output produced by an asset of age t, the cost measure computed implicitly accounts for differences in productivity over time. A more complete discussion of this approach is contained in Burt (1992).

The approach assumes time to be discrete and that the economic life for the asset is known (as opposed to random). All monetary values are implicitly defined with respect to the purchasing power of money at a single point in time, i.e., adjusted for inflation when measured over time. All interest rates are then assumed to be real. Consider an asset with acquisition cost or purchase price at the beginning of year one of V_0 and a net salvage value at the end of year n of V_n. The output produced using this asset in year t of its of life is denoted Q_t. For an orchard this might be the bushels of peaches produced which varies over the life of the orchard. For a dairy cow it might be milk production per year which will fall in the later years of the cows life. Similarly with a stand of alfalfa. For a tractor the output might be quality adjusted hours of service potential. For example, a five-year-old tractor that has been used 200 hours per year (1,000 total hours) may have a different service capacity than a 20-year-old tractor that has been used 50 hours per year. The idea behind valuing the remaining service differently is that an hour produced by an old machine might be of less value than an hour produced by a newer machine due to more likely frequency of breakdown by the older machine. Let the annual operating and maintenance outlays (including labor) associated with the asset be denoted C_t. These, as well as output, are assumed to occur at the end of the year for simplicity. The implicit rent on the asset in period t is given by

$$\text{implicit rent} = uQ_t - C_t \tag{6A.1}$$

where u is defined as the nonnegative unit cost for the service flow Q_t. For a given replacement age n, the present value of rents plus net salvage value set equal to purchase price V_0, i.e., unit cost is implicitly determined by

---

[1]The unit cost measure defined here was called "unit cost plus" by Taylor to distinguish it from a simple measure that ignored interest costs, but later writers called it simply "unit cost." Hotelling used the term "theoretical selling price" for what is here called unit cost.

$$V_0 = \sum_{t=1}^{n} \beta^t (uQ_t - C_t) + \beta^n V_n \tag{6A.2}$$

where $\beta = \frac{1}{1+r}$ and r is the real interest rate. Solving 6A.2 for u gives

$$u = \frac{[(V_0 - \beta^n V_n) + \sum_{t=1}^{n} \beta^t C_t]}{[\sum_{t=1}^{n} \beta^t Q_t]}. \tag{6A.3}$$

Unit cost is quite intuitive economically; it is the present value of all costs minus the present value of salvage, all divided by a weighted sum of output over the life of the asset where the weight at age t is the present value weight β^t (discounted value of total output measured in physical units).

After incurring the initial investment cost (V_0), the present value of the remaining services in the asset at the end of period t would be

$$V_t = \sum_{j=t+1}^{n} \beta^{j-t} (u Q_j - C_j) + \beta^{n-t} V_n \tag{6A.4}$$

for t = 0, 1,...n. Note that V_0 defined by 6A.4 is simply the right-hand side of (6A.2). The annual economic depreciation (ED_t) charges are given by

$$ED_t = V_{t-1} - V_t. \tag{6A.5}$$

These charges will sum to V_0 - V_n and so are what is called accounting admissible. The summation of ED_t in (6A.5) from t=1 to t=n yields canceling terms in V_t, t = 1,2,...n-1, which leaves V_0 - V_n. The unit cost u is then a charge per unit of output that can be incorporated in cost of production estimates. It is a constant per unit charge that reflects the full cost of owning and operating the asset over its useful life. It accounts for differences in the output and operating costs associated with the asset at different times in its productive life with full recognition given to the time distribution of the services and costs.

The estimation of unit cost is simplified considerably when output Q_t is constant over age of the asset because uQ_t reduces to a constant over time. Denote this constant by $u\bar{Q} = a^r$. If we substitute for uQ_t in 6A.2 we can derive a constant annual charge,

$$a^r = \frac{[(V_0 - \beta^n V_n) + \sum_{t=1}^{n} \beta^t C_t]}{[\sum_{t=1}^{n} \beta^t]} \qquad \textbf{(6A.6)}$$

To better interpret 6A.6 rewrite the denominator as

$$\sum_{t=1}^{n} \beta^t = (\frac{1}{1+r} + \frac{1}{(1+r)^2} + \quad + \frac{1}{(1+r)^n}) = US_0(r,n) \qquad \textbf{(6A.7)}$$

following equation 2B.7. Rewriting 6A.6 by using the alternative definition of $US_0(r,n)$ from equation 2B.8 and writing $\left[\frac{1}{1+r}\right]^t$ for β^t we obtain

$$a^r = \frac{\left[\left(V_0 - \frac{V_n}{(1+r)^n}\right) + \sum_{t=1}^{n} \frac{C_t}{(1+r)^t}\right]}{US_0(r,\ n)}$$

$$= \frac{\left[\left(V_0 - \frac{V_n}{(1+r)^n}\right) + \sum_{t=1}^{n} \frac{C_t}{(1+r)^t}\right]}{\left(\frac{1 - \frac{1}{(1+r)^n}}{r}\right)} \qquad \textbf{(6A.8)}$$

which is the real version of equation 2C.3 assuming no operating or maintenance costs at time zero. Thus when output is a constant over time u reduces to

$$u = \frac{a^r}{\bar{Q}}. \qquad \textbf{(6A.9)}$$

This is the same as the common approach used to derive a cost per unit of service where the annual charge is divided by the hours of use or units of output to get a cost per unit of service. For machinery this would imply dividing the cost per year by the number of hours of use to get a cost per hour.

Economic depreciation is still given by (6A.5). The present value of the asset at the end of year t from equation 6A.4 can be written in this case by substituting a^r for uQ_j as follows

$$V_t = \sum_{j=t+1}^{n} \beta^{j-t}(a^r - C_j) + \beta^{n-t} V_n . \qquad \textbf{(6A.10)}$$

The difference in the computation of u using 6A.3 and as opposed to 6A.8 and 6A.9 makes it clear that in the general case of (6A.3), one cannot simply calculate unit cost by a proportional adjustment to annual cost of owning the asset as in 6A.9.

In (6A.8) a^r is a real annuity representing the amortized present value of the costs of owning and operating the asset, but in (6A.3) the unit cost of service from the asset depends on the sum of the product of the discount factor and the amount of services from the asset each year throughout the future life of the asset, not just the discount factor alone. Consequently, the cost of a specific number of units of service from an asset cannot be calculated from the amortized present value of costs associated with ownership of the asset unless the quantity of services is constant during each period in the life of the asset; the distribution of services from the asset over its life is an intrinsic part of the weighting required to calculate unit cost of the services. It is intuitively clear from (6A.3) that a relatively large number of services provided early in the life of the asset relative to later in its life will tend to reduce unit costs and vice versa. This may be particularly important for machinery assets where timeliness and absence of breakdowns is essential for efficient planting and harvesting of crops during small windows of favorable weather. In such situations, additional repair expenditures may not compensate for poorer performance by an older machine. In such cases, the separation of operating costs (maintenance and repairs) from ownership costs as suggested by this report may be inappropriate and the more complicated formula in equation 6A.3 should be considered. This may be particularly relevant for assets such as perennial crops or breeding livestock where productivity is clearly changing over the lifetime of the asset. For a further discussion see the Appendix 10B.

APPENDIX 6B

Alternative Forms of the Equation for a Real and Nominal Annuity for Calculating Capital Costs

The preferred method to compute economic depreciation and opportunity cost for a capital asset is to calculate the real or nominal annuity that has the same net present value as the stream of cash flows associated with holding the asset for a number of periods. This is presented in the text as equation 6.7. Equation 6.7 is identical to capital budgeting where original cost less the present value of the salvage value of the asset is amortized over its life. Equation 6.7 is the same as equation 2.31 where V_n is in real terms and CSC is the capital service cost expressed as an annuity. The real version of equation 6.7 can also be written in an alternative fashion as in equation 6.8. The steps in going from 6.7 to 6.8 are as follows

$$
\begin{aligned}
CSC &= \frac{\left(PP - \dfrac{SV}{(1+r)^n}\right)}{\left(\dfrac{1 - \dfrac{1}{(1+r)^n}}{r}\right)} \\
&= \frac{\left(PP - \dfrac{SV}{(1+r)^n} - SV + SV\right)}{\left(\dfrac{1 - \dfrac{1}{(1+r)^n}}{r}\right)} \\
&= \frac{\left(PP - SV + SV\left(1 - \dfrac{1}{(1+r)^n}\right)\right)}{\left(\dfrac{1 - \dfrac{1}{(1+r)^n}}{r}\right)} \qquad \textbf{(6B.1)} \\
&= \frac{(PP - SV)}{\left(\dfrac{1 - \dfrac{1}{(1+r)^n}}{r}\right)} + \frac{SV\left(1 - \dfrac{1}{(1+r)^n}\right)}{\left(\dfrac{1 - \dfrac{1}{(1+r)^n}}{r}\right)} \\
&= \frac{(PP - SV)}{\left(\dfrac{1 - \dfrac{1}{(1+r)^n}}{r}\right)} + (SV)(r).
\end{aligned}
$$

A nominal form of equation 6.8 (6B.1) can also be developed. In this case the salvage value must be in nominal dollars. The real value at time 0 is multiplied by $(1+\pi)^n$ to adjust it forward n periods. The nominal version of 6.7 is then given by

$$CSC = \frac{\left(PP - \frac{SV(1+\pi)^n}{(1+i)^n}\right)}{\left(\frac{1 - \frac{1}{(1+i)^n}}{i}\right)} . \tag{6B.2}$$

This can be modified to give an equation similar to 6.8 as follows

$$\begin{aligned}
CSC &= \frac{\left(PP - \frac{SV(1+\pi)^n}{(1+i)^n}\right)}{\left(\frac{1 - \frac{1}{(1+i)^n}}{i}\right)} \\
&= \frac{\left(PP - \frac{SV(1+\pi)^n}{(1+i)^n} - SV(1+\pi)^n + SV(1+\pi)^n\right)}{\left(\frac{1 - \frac{1}{(1+i)^n}}{i}\right)} \\
&= \frac{\left(PP - SV(1+\pi)^n + SV(1+\pi)^n\left(1 - \frac{1}{(1+i)^n}\right)\right)}{\left(\frac{1 - \frac{1}{(1+i)^n}}{i}\right)} \qquad (6B.3) \\
&= \frac{\left(PP - SV(1+\pi)^n\right)}{\left(\frac{1 - \frac{1}{(1+i)^n}}{i}\right)} + \frac{SV(1+\pi)^n\left(1 - \frac{1}{(1+i)^n}\right)}{\left(\frac{1 - \frac{1}{(1+i)^n}}{i}\right)} \\
&= \frac{(PP - SV(1+\pi)^n)}{\left(\frac{1 - \frac{1}{(1+i)^n}}{i}\right)} + SV(1+\pi)^n(i) .
\end{aligned}$$

CHAPTER 7

LAND

Land is the solid part of the earth's surface. Its value in agriculture is tied to its capacity for providing services used to produce an agricultural product. Part of land's agricultural use value is a result of the climate that dictates the length of the growing season, available rainfall, and other determinants of the crops that can be produced and the risk involved.

Land has at least two distinguishing characteristics. The first is its location fixity. As a result of land's location fixity, if the control of land is to be transferred, the users of the land must relocate their production activities. Land's second distinguishing characteristic is its ability to maintain over time and use its physical qualities that give it value. **Capital** was defined in Chapter 2 as a stock that is not used up during a single production period, provides services over time, and retains a unique identity. Land is thus clearly a capital input. And because land can exist for a long time without significant deterioration, it is also considered to be a durable input as discussed in Chapter 6. Land that can exist for an infinitely long time without significant deterioration is referred to as an infinitely lived durable.

Most analysts recognize that the two properties of land, location fixity and long if not infinite life, are approximations of reality. For example, land in sod farms is indeed transferrable. Moreover, lack of proper maintenance may result in land losing some of its physical properties that give it value in a short period of time. Still, land serves as a reference point for defining an asset whose physical properties are long lasting and cannot be moved except with considerable effort and cost that is usually considered prohibitive.

Land is differentiated from real estate inasmuch as real estate includes capital structures attached to the land. Capital structures such as buildings, grain bins, and fences are durable assets that can be removed and their services obtained at a different location. These types of structures are treated as durable assets and are not included in the costs or services of land. Other capital structures that are a part of real estate such as wells, terraces, levees, leveling, and tiling become part of the land and acquire its properties of being immovable and durable. These investments are not transferrable but depreciate over time. Because services of these investments cannot be transferred to another location, even though they can be removed (negative salvage value), they are usually treated as part of the land. When rental rates are used to estimate the cost of land use, the cost of these investments will typically be included in the rental rate. If the cost of land use is estimated using an ownership approach, these capital items should be handled using capital recovery as discussed in Chapter 6. If land preparation costs are specific to a given enterprise and are used up over several production periods, they should be handled as preproductive costs as considered in Chapter 10. Water rights may be considered part of land if these rights are not transferrable; or, they may be considered to be separate from land if they can be separated from the land, as discussed in Chapter 9.

Chapter 7. Land

TERMS AND DEFINITIONS

A distinction between land's agricultural use value and its market value is required to measure costs and returns (CARs) associated with agricultural land use. It is also important to recognize that in some cases, the agricultural use value of land differs from its market value. One explanation for the difference may be the expectation that land will be used in nonagricultural activities beginning at some future date. For example, land close to an urban center may have a high price based on expected value in residential housing. Another explanation is that land earns nonagricultural returns concurrently with agricultural returns as may be the case where a producer is able to extract a payment during winter months for hunting or trapping. The importance of distinguishing between land's agricultural use value and its market value is that not all CARs associated with land should be charged to land's agricultural use.

Ownership of land entitles an individual to the control of the sum total of natural and manmade resources associated with the land (Barlowe: 8). What is being controlled is a resource with value that if liquidated would, with the passage of time, generate a return. The value of this resource, as has been stated already, is its current agricultural use value. The foregone return associated with land's agricultural use represents land's opportunity cost. Conceptually, the opportunity cost of land would be approximated by multiplying the current agricultural value of the land by an appropriate interest rate, thus giving a perpetuity with the same present value as ownership of the land's agricultural use value. A more detailed discussion of interest rate choice is presented in Chapter 2. Finally, opportunity cost is not the same as the cost of financing land. Financing land purchases is not part of land ownership costs because land purchases reflect alternative means of acquiring or controlling land and are often tied to acquisition costs rather than use values. Moreover, trade-offs are often made between the sale price of land and the interest rate charged, as in some land contract sales.

Besides opportunity cost, property taxes are the other major cost of owning land. Consistent with the distinction between agricultural use value and land's market value, only the portion of property taxes reflecting land's agricultural use value should be included as an agricultural land cost. Several states have no property tax. Many other states already have some form of a greenbelt tax law in which agricultural land is taxed at its agricultural use value.

The **maintenance costs** of holding a capital asset such as land are the expenses required to maintain the service potential of the asset at a reasonable level and to extract services for a single time period. Maintenance costs for land are thus those costs required to restore land to its approximate service potential at the beginning of the period or to prevent its deterioration during the period. Whether or not they are actually incurred is immaterial. They represent costs associated with actual deterioration or the cost of preventing deterioration of land and should be accounted for in cost estimates of using and controlling land. Land incurs **service reduction costs** because the **service capacity of land is altered** as a result of use or the passage of time. Costs required to restore service capacity as a result of **use** are referred to as **user costs**. Losses in service capacity as a result of the **passage of time** are referred to as **time costs**.

ESTIMATING THE VALUE OF LAND'S AGRICULTURAL CONTRIBUTIONS

In practice, it may be difficult to estimate separately the opportunity costs, user costs, time costs, property taxes associated with agricultural use value, and other overhead costs (general liability insurance, irrigation district assessments independent of water use, etc.) of holding land (Robison and Koenig). Property taxes associated with the agricultural use value of land require precise measurement of land's agricultural use value, which is not easily obtained. For the same reason, we are often unable to estimate precisely opportunity costs associated with land. Finally, use or time costs are difficult to measure when land markets are thin and do not provide a sufficient number of observations to make reliable estimates. At the same time, there are active land markets in many areas, and in areas with less active markets, rural appraisers, farm management consultants, and local producers may be able to approximate the agricultural value of land currently being used for agricultural production.

A problem similar to separating land's agricultural use value from its market value is encountered when decision makers desire to construct enterprise CAR estimates when more than one enterprise share the use of the land. Because land costs are frequently calculated as a residual measure, any attempt to allocate returns from enterprises using the same land allocated between the several factors of production including labor, management, risk, capital, and land will be arbitrary.

Land Tenure Considerations

Access to rights to use of land may be gained through alternative tenure arrangements. These may be acquired through ownership, cash rental for a specified period, or share rental for a specified period and use. The tenure method used to acquire rights to use of land affects production risks, production costs, and production returns to both the entrepreneur and land owner. Modal tenure patterns for rights to land use differ greatly among geographic areas and among land quality within areas as well as among production enterprises within areas.

The owner-operator receives the full return from production of the enterprise, experiences all cash costs associated with production, bears all production risks, and experiences both cash and noncash costs of land ownership and maintenance. The owner-operator views the costs of land as a fixed residual cost, and treats them as such in production decisions. These land costs include all land directly associated with production enterprises as well as land associated with the firm as an entity used for service areas and waste lands not suitable for production.

The cash rent tenant-operator receives the full return from production of the enterprise, experiences all cash costs associated with production, including a cash cost for land use, and bears all production risks. The land use cost is thus a variable cash cost to the cash rent tenant-operator and is treated as such in production decisions. The cash rental charge may reflect only production acreage or total land area in the farm unit, depending on whether the contract was for production of a specific enterprise or for the farm unit including service areas. **It is extremely important to determine whether a cash rental rate is for tillable (and expected to be planted) acres or for total acres**

including acres not devoted to production because this will affect the cost of land per productive acre. The landowner renting the use of land on a cash rent basis experiences no production risks and receives a fixed rate of return for the time period specified in the rental contract, subject to variations in supplemental returns associated with program payments for government-supported crops. The costs of land to the landowner who cash rents production rights to a tenant are reflected as a fixed residual cost to the landowner, subject to variations in maintenance costs that may be specified in the cash rental contract.

Share rental tenure arrangements are much more complex and vary greatly among production enterprises, land quality, and geographic areas. Share rental arrangements substantially alter both cost structure and production risk for both landowner and tenant. Both landowner and tenant share production returns and production risks, the proportionate shares for each varying by production enterprise, land quality, and proportion of cash production expenses shared. Production risk may be altered by the proportionate shares of selected cash production costs borne by each. Thus the share tenant-operator receives only part of the production returns and experiences land use costs as a variable reduction in receipts. The tenant-operator bears all or part of the cash production expenses, dependent upon terms of the share rental contract, and faces a substantially altered marginal cost–marginal returns structure compared to the owner-operator or cash tenant-operator. The landowner in a share rental tenure arrangement is a much more active participant in agriculture production activities than the landowner in a cash rental tenure arrangement. The costs of land use are reflected to the landowner in a share rental tenure arrangement as a fixed residual cost, and are treated as such in production decisions.

ESTIMATING LAND COSTS

All the land cost estimation complexities described in the previous section lead us to look for alternative ways to estimate costs associated with the use of land in agricultural production. Since land tenure patterns differ substantially among regions and type-of-farming situations, it may be appropriate to use different procedures for estimating land costs in order to minimize bias in land cost estimates among situations.

Alternative 1 for Estimating Land Costs

Cash rent paid for land used to produce an agricultural product best measures the sum of opportunity costs, time costs, user costs, property taxes, and other overhead costs associated with land's agricultural use value in those situations where a significant proportion of the agricultural land is farmed under cash rental tenure. Cash rent paid for the use of land in agricultural production is the amount of compensation the land owner requires from the tenant to pay for property taxes on the agricultural use value of the land, opportunity costs, time costs, and user costs. Because the tenant does not receive capital gains on the land, cash rent does not include the value of anticipated gains (losses) due to inflation or potential future nonagricultural use of the land. Rental rates also reflect what tenants are willing to pay to avoid the payment of property taxes on the land they intend to use for producing agricultural products and to avoid the payment of opportunity costs (on the agricultural value), time costs, and user costs.

Cash rent does not include payments to financial capital, risk, and management, because in most cases the tenant is not acquiring them and would not be willing to pay for them. Only if the landlord absorbs some of the production risk, supplies capital, or provides management does the rental rate include charges for these factors of production. In a share rental agreement, for example, the landlord is sharing in the production risk and the payment he/she receives must compensate for the risk. But in a typical cash rental agreement, the tenant is acquiring only the temporary use of the land to produce an agricultural product and therefore is willing to pay for only the land's services used in agricultural production during the production period. Thus, the rental rate willingly paid by the tenant and accepted by the landlord is the best estimate of land's agricultural use for use in CAR estimation.

Cash rental rates are probably the most reflective indicator of current market conditions in agricultural production areas where a significant proportion of the agricultural land is farmed under cash rental tenure. However, these estimates suffer bias resulting from a number of factors. Cash rental rates usually apply to the use of the land for a specific agricultural production enterprise, with the rental charge differing among enterprises. All agricultural production enterprises do not share proportionately in the land rental market, whether it be cash or share rent. Some enterprises are predominantly cash rent whereas others are predominantly share rent, differing by geographic area. In some geographic areas the cash rental market represents such a small portion of the agricultural land that cash rental rates do not reflect production values of land, but rather tend to reflect land of marginal quality or, frequently, favorable treatment in family land use transactions. As mentioned previously, it is important to determine what is included in “one acre” of land. The effective cost to the production enterprise will differ depending on the whether this acre contains grass waterways, extensive headlands, irrigation ditches, buffer strips, or windbreaks, power lines (or substations), and/or barren hilltops.

Alternative 2 for Estimating Land Costs

In some situations, share rentals may provide the most accurate reflection of current market use value for land, particularly in areas where share rental is prevalent for particular production enterprises. Because share rental arrangements are quite flexible, differing among individuals in the proportions and specific production costs shared, modal or typical rental rates are more difficult to identify and quantify. Estimates will suffer from bias because, frequently, the cost sharing consists of cash costs for the landowner and both cash and noncash costs for the tenant. While share rental rates can be converted to a cash-equivalent value, they should not be treated as cash rents because they affect CARs for both the tenant and the landlord.

The following example illustrates the calculation of a cash-equivalent value for a share rental arrangement. Assume a two-fifths crop-share agreement for soybean production where the landlord receives 40% of the receipts and pays 40% of the cost of seed, pesticide, and insurance. Further assume a soybean yield of 42 bushels per acre valued at $5.50 per bushel, and seed, pesticide, and crop insurance expenditures amounting to $27.08 per acre. The calculated cash-equivalent land rental value would then be $81.57 [(0.4)(42)($5.50) - (0.4)($27.08) = $81.57]. In this situation the share tenant experiences a reduction in cash receipts of $92.40 and a reduction of $10.84 in cash operating costs in lieu of a cash rental payment.

Alternative 3 for Estimating Land Costs

In areas where farmland is operated almost exclusively by owner-operators, rental rates may not provide meaningful estimates of fair market value. When reasonable estimates of the market price of land for agricultural purposes can be obtained, an implicit annual rental fee can be obtained using standard capitalization techniques. The market price of land for agricultural purposes times the real interest rate (adjusted for risk), plus annual maintenance costs, plus annual net real estate tax will provide the least biased estimate of annual real use cost. A real interest rate is appropriate for capitalization because the Task Force suggests that all CAR estimates be in real (and nominal) terms as of the end of the production period, and that all CAR streams outside of the current period be estimated in real terms. The appropriate choice of a real interest rate is discussed in Chapter 2. Following the conventions established in Chapters 2 and 6, the land value used should be in end-of-year terms so that the implied annual payment represents the real end-of-year value for holding the land for one year. If the agricultural land value is in beginning-of-year terms, it should be multiplied by the current inflation rate to put it in end-of-year terms before computing the opportunity cost equivalent. As an example, consider an acre of land with an agricultural value of $2,163 per acre as of the end of the year. If the real interest rate adjusted for risk in agriculture is 5%, then the implied opportunity cost is $108.15 per acre. Charges for property taxes (say $20 per acre) and maintenance (say $3 for fence row weed control) would bring the annual cost of using the land to $131.15 per acre. If the value of the land in beginning-of-year dollars was $2,100, it should be adjusted to the end of the year by the inflation rate. If the inflation rate was 3% per year this would give an end-of-year value of $2,163 and an implied opportunity cost of $108.15.

Alternative 4 for Estimating Land Costs

When market sales of land that represent agricultural use value are not available, a more complex procedure is required to obtain reasonable estimates of agricultural use cost. This means that it is necessary to accurately assess land use in the areas by identifying the proportion of total land in farms that is used for production enterprises and identifying the proportion of production acreage devoted to each production enterprise. A relevant current period must be specified for defining yields and production costs to be used in calculating the annual returns to land for each production enterprise and computing a composite annual rent value. This composite per acre value would be equivalent to a cash rent value and would require no adjustments for taxes or maintenance costs because it represents agricultural returns to ownership. As was the case for alternative 3, the land use cost is a residual claimant for the owner-operator, even though it is composed of both cash and noncash components.

The following is an example of the procedure for computing a composite per acre cash rental value estimate. Assume an agricultural production region for which corn and soybeans are the two predominant crops. Further assume that 50% of the land area is planted to corn, 40% is planted to soybeans and 10% is devoted to service areas, drainage ways, and waste. Additionally assume that based on the most recent five-year period for yields and costs, CAR estimates provide estimated per acre annual net rents of $85.00 for corn production and $70.00 for soybean production. The calculated composite cash-equivalent annual rental value would be $70.50 [(0.5)($85) + (0.4)($70) + (0.1)($0)].

CONCLUSION

Several alternative methods for estimating the cost of land use in agricultural production have been presented. These include cash rental rates, cash-equivalent values based on share rental agreements, estimating land's agricultural use value directly by summing opportunity costs, property taxes, time costs, and use costs, and a composite rental rate for all commodities in a certain geographic area.

The Task Force's preferred measure of the cost of land used in agricultural production is the cash rental rate where a significant proportion of the agricultural land is farmed under cash rental tenure.

Regardless of the method chosen for estimating user costs of land, it is imperative that appropriate adjustments be made to account for nonagricultural factors in value and/or cost; differentiation between land area directly devoted to production enterprises and land associated with the farm firm unit; and shared returns/costs associated with tenure arrangements, marketing agreements or contracts, and government program participation. Ignoring these factors or making superficial adjustments for their influence will result in substantially biased estimates that render comparative land user costs among regions and among tenure groups within a region meaningless.

CHAPTER 8

LABOR AND MANAGEMENT:
FARM LABOR AND RELATED SERVICES

Labor is one of the most important inputs in agricultural production. How it is measured and valued is critical for establishing the cost of producing agricultural commodities and accurately portraying labor's relative share of the total cost of production. Historically, in agricultural commodity cost and return (CAR) methods, labor and management have been treated as distinct, unrelated, or disconnected inputs. A variety of reasons undoubtedly exists for this separation. The perspective that leads to a separation of labor and management, however, is not useful to clear thinking about CAR estimates because human capital, including allocative ability, and human time of an individual are inseparable and jointly allocated (Huffman, 1985).

Two major categories of farm labor are proposed: (1) hired labor without farm ownership claims, and (2) unpaid farm labor and salaried farm labor having ownership claims. A comprehensive accounting procedure is recommended for the farm labor input in ways that will most likely increase recognition of the quantity of unpaid farm labor used in farming. The cost of hired farm labor (type 1 farm labor) is total producers' costs, including wages, salaries, fringe benefits, and other hired labor associated costs. Several alternative methods for valuing unpaid farm labor and salaried farm labor having ownership claims are evaluated, including the most preferred opportunity cost method. The particular opportunity cost is the off-farm wage, paying careful attention to point-in-time availability or use and quality dimensions (for example, years of schooling completed, years of postschooling experience) and local economic conditions (high or low structural unemployment rates, unusually attractive or unattractive local amenities, and unusually high or low trend growth of employment). Thus, the cost of a farm operator's labor in farming can be forecast from a wage equation, given the operator's characteristics, and local economic conditions. We suggest procedures for producing and distributing this information.

The recommended procedures for farm labor and related services will lead, in general, to higher estimated costs of operators' unpaid farm labor than procedures that use the average local wage rate for hired farm labor as the cost and use engineering estimates of labor use. Higher costs occur because in most situations both the per unit cost and total number of units of labor will increase.

TERMS AND DEFINITIONS

Laborers or workers are defined as the number or inventory of persons at a point in time. Workers are generally heterogenous because of differences in productive skills, location, and availability for work. Labor is a service (person-years per year) and includes all human time-using activities, including what is sometimes labeled separately as labor and management. Labor services are perishable and hence cannot be moved to another period in time for use; workers, on the other hand, are durable, potentially working for many years as well as being geographically mobile.

Chapter 8. Labor and Management: Farm Labor and Related Services

Farm labor includes all hired, contract, exchange, and unpaid family labor used in agricultural production. Farm labor is defined here to encompass what is sometimes distinguished as traditional labor, management, and other overhead time, and also includes labor acquired through farm labor contractors and all semiskilled services used in farming, such as mechanics for machinery and building repair, and bookkeepers.

A broad definition of labor and related services makes for a relatively homogenous input category over time, as specialization and change in the economic organization of farms and of our economy occur. All units of farm labor are not assumed, however, to be the same with respect to skill, location, and availability or period of use. Suggestions that hired labor is a fixed input are not compelling, except in the very short run. Even when a farmer makes a contract for a month (or year) with a worker for a certain number of hours of labor, there is generally considerable flexibility about exactly when and what work is done. Thus, labor that might sometimes seem to be "fixed" is really "variable."

Services of highly skilled professionals such as lawyers, tax accountants, and veterinarians are not included in the definition of farm labor and related services because these individuals possess skills from human capital investments and specialization that are very different from the skills possessed by farmers and ranchers. As a result, these services are not "close" substitutes for farm labor as defined here. Costs associated with the services provided by such skilled professionals should be reflected in other input expense categories.

OPPORTUNITY COST OF FARM LABOR

The opportunity cost of farm labor is the maximum value per unit among the alternative uses of that labor. Skill or human capital, location, and period of use are generally important factors for determining the opportunity cost of farm labor. **For hired farm labor (no ownership claim), the compensation (wage plus cost of benefits) is the opportunity cost.**

Though unpaid farm labor does not generally receive a wage, it does have an economic cost. **Implicit compensation for unpaid farm labor is based on the opportunity cost of off-farm work, or the return available in the next best alternative use of this labor time and effort.** As long as adjustments are made for labor quality or effective labor units so that implicit wages measure effective labor market skills, cost of production estimates will not be affected greatly by whether hired or unpaid labor is employed in farming or nonfarming enterprises. To the extent that there are specific human capital skills or experience associated with particular agricultural enterprises, there may be minor differences between the opportunity wage of an individual working on a particular farm, on another farm, or in the nonfarm sector. When farming enterprises differ in their technologies and, at the same relative input prices, have different labor intensities of production, the decision maker who sets the price of labor "too low" is giving (at least on paper) an absolute and relative cost/profit advantage to the most labor-intensive enterprise(s). This means that both absolute and relative marginal costs of production will be distorted, resulting in nonoptimal allocation decisions. Note that for a given farm, "homogeneous" labor will have the same cost across all farming enterprises.

QUANTITY OF FARM LABOR

Measuring labor as the number of workers or employees is using a stock item to approximate a service. All workers generally do not work the same number of hours per period and are different in ways that affect the quality of a unit of service. Thus, approximating farm labor by the number of workers or by assuming a uniform rate of conversion from stock to flow, such as eight hours per day, is not a recommended practice.

Measuring farm labor as person-hours per period used in farming is the appropriate services measure. Homogenous labor can be aggregated by adding together hours in the same period. Surveys of labor availability and possibly time-and-motion studies can provide the details needed for good labor quantity measures. Heterogenous labor should not simply be added together to obtain an aggregate because if the labor is available in different periods, intertemporal transfer is generally impossible and it is costly to change the skills or geographic location of workers. Thus, measuring available farm labor or farm labor use by adding up annual hours of work is not a generally recommended practice.

When heterogenous farm labor must be aggregated, an index created as the price-weighted hours has major advantages. In this approach, hours of labor provided at a higher price receive a greater weight than those associated with a lower price. This practice reflects the fact that opportunity costs are greater for higher-priced labor. A price-weighted labor index can be thought of as being expressed in efficiency units. Although two farms may be using the same physical units of farm labor, one of them may have more "effective" labor because it is using higher-quality labor. As an example, a dairy farm employee responsible for bST injections, artificial insemination (AI), and supervision of dairy parlor operations may receive a much higher wage than an individual who milks cows or fills feed bunks. Similarly, the cost per hour for individuals to pick apples may be higher during some periods than others.

The choice between alternative methods to estimate the quantity of farm labor is influenced by the type of information available and the purpose of the estimation. Accurate farm labor data are frequently difficult to obtain. One approach is to estimate labor hours from input-output relationships, engineering coefficients, or labor requirement data. For example, in the Upper Midwest Dairy Farm example, Tables 14A.1-14A.4 contain machine use coefficients that are sometimes used to generate labor use (for example, 100 hours of field cultivation requires 100 hours of labor and 100 hours of machine services). Farm labor data created from this method tend to underestimate "true" labor use, even for these machine operations, unless they are specifically calibrated to labor surveys. The use of labor coefficients often ignores important labor quality differences. For example, the skill level and labor time required per hour of operation for operating an ultra-modern combine using a global positioning system (GPS) and special yield monitors may be very different from the time and skill needed per hour of machine time in operating a field cultivator. The use of machine time coefficients also ignores the time required for other tasks associated with production, some which may be substantial. Labor requirement data are particularly vulnerable to rapid changes in technology. When machine time coefficients are used, it is important to calibrate them to surveys as much and as frequently as possible, and adjust them to account for total labor use. Labor quantity estimates developed using input-output coefficients tied to specific tasks are most useful for projected CAR estimates where actual data on labor use are not available.

A better alternative for estimating farm labor quantities is to survey farmers concerning actual use. There are two general types of surveys used to obtain labor quantity data: whole-farm surveys designed to measure the total quantity of labor utilized in the operation over some time period, and task-specific surveys that ask for detailed information on the total time (machine operation, downtime, time to field, etc.) required to perform well-defined tasks such as disc one acre of cornstalks in the spring on firm soil with a 22-foot disc and a 140-HP tractor. While a large detailed survey could conceivably collect both types of information simultaneously, expense has generally dictated separate surveys, or surveys that collect whole-farm data along with specific surveys on a small number of tasks. Whole-farm surveys are particularly important for obtaining data on labor costs associated with allocated overhead, such as time spent planning, on farm bookkeeping, on analysis of records, on collection of information, and so forth. In many instances labor data are collected as part of a survey designed primarily for other purposes and must be combined with nonsurvey information in order to estimate economic costs.

For historical CAR estimates, the recommended procedure, after obtaining a whole-farm estimate from a farm operator of the total amount of labor (hired and unpaid) used in a farm business during some period (say a year), is to have the operator allocate the share of each of the major types (or cost) of labor to each major commodity or enterprise. A tableau similar to the one in Chapter 5 on operating costs for machinery, equipment, and buildings, or to the one in Chapter 9 on joint costs may be useful in this regard. It is important that information be collected in a way so that shares sum to one (or 100 percent).

The state of knowledge about how to conduct good surveys of time use is quite advanced (Juster and Stafford) and with the use of appropriately worded questions, farmers can make reasonable estimates of the use of unpaid farm labor. For example, fairly accurate information on hours of farm labor by a farm operator can be obtained by the following procedure. First, identify the farm operator (or farm operators) for a farm. Second, ask each operator how many hours were allocated to farm work (broadly defined), to off-farm work, to work around the house, and to all other activities during the last month (week). This type of question has the advantage of having a control total on hours allocated by a given individual to all uses of time during a day. Thus, an error in the estimate of one use of time causes an offsetting error in the opposite direction in other uses of time. Using this procedure, most individuals have a relatively good perception of how their time is allocated to major activities.

Although using subjective information provided by farmers about the total time spent on farm work is a reasonably accurate way to estimate total labor use, farmers can be expected to present much less reliable information about how they allocate their time to particular farming activities or commodities than about the total time used. There are several reasons for this outcome. First, farmers are frequently engaged in a fairly wide range of activities during any day, week, month, or year. Human recall for small details is difficult for everyone (Juster and Stafford). Second, farmers frequently use time that affects more than one commodity or enterprise and have zero output from some enterprises that take time to consider in a production plan. Thus, estimating exactly how much is to be allocated to each enterprise or commodity is often arbitrary.

When the purpose of the analysis is the construction of cost estimates by enterprise or commodity, allocation of some type is required and so the researcher must proceed with the best method available.

Regardless of the approach taken to estimate the quantity of farm labor, a supplemental schedule to the CAR statement should be developed which reflects the number of different types of farm labor used in producing agricultural commodities. The statement should have one category of hours for the major decision maker(s) of a farm. Most of allocated overhead labor would be in this category. For hired labor with no ownership claims, there should be a category for each different skill availability type. The categories might be (i) farm operator hours (male vs. female), (ii) spouse, (iii) other unpaid farm labor (male vs. female), (iv) hired labor, full time and seasonal, (v) contract farm labor, and (vi) hours of related labor services (by major type). An ideal example of how this statement would be prepared is shown in Table 8.1. Although it may not be possible to obtain this level of detail in many surveys, this example gives a starting point from which to design a survey instrument.

COSTS OF FARM LABOR

In considering costs, it is useful to distinguish hired labor (that does not have an ownership interest in the farm business) from unpaid labor and labor that is paid a salary and has an ownership interest in the farm business. The reason for including individuals who have both a salary and ownership claim in the same category is that no good reason exists for the salary of these individuals to be related closely to their labor input in the farm business. The salary might be either a significant under- or overstatement of contribution, or misstated in terms of timing because of tax and financial reasons.

Hired Labor (No Ownership Claims)

> ***The Task Force recommends that hired labor with no ownership claims and related purchased services be valued at the wage rates (regular or piece rate) plus fringe and other benefits for contract farm labor.***

Thus, the "full cost" per hour is more than the regular wage rate, and frequently is 10 to 15% higher.[1] These fringe and other benefits include the following: the employer's contribution to social security, workman's compensation and retirement plans; the value/cost of time spent screening and training new workers; paid vacation and sick leave time of workers; health insurance; and employer housing, food, and transportation costs. If specific labor services are always hired at lower rates due to local labor market conditions (surplus of student labor, large number of individuals seeking summer-only employment, availability of retired

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[1]This is based primarily upon the fact that benefits to workers in the nonfarm sector are currently slightly greater than 25% of the wage and salary cost, and the share has been increasing rapidly since the mid-1980s. In aggregate studies, a wage or compensation index can be obtained as hours-weighted-average compensation or converted to a Törnqvist compensation index (see Chambers: 243-49). An index that uses only the wage, excluding benefits, will underestimate unit labor cost for agriculture by at least 10%.

individuals who "enjoy" the work, etc.), the tasks performed by these individuals could be broken out in estimating labor quantities, and the appropriate wage rate applied to these transactions.

TABLE 8.1 Categories of Labor and Related Services

Hours of Farm Work and Quality Attributes:

i) Operator (by age, education, experience, gender, race, etc.)

ii) Spouse (by age, education, experience, etc.)

iii) Other unpaid or with ownership claims
  Adults (age, education, experience, etc.)
  Children: 16-18 years of age
    < 16

iv) Hired farm labor (no ownership claims)
  Full-time (by age, education, experience, etc)
  Seasonal (by type)
  Part-time (by type)

v) Contract labor (by type)
  (Expenditures also)

vi) Related Services
- Mechanical repairs and maintenance
- Bookkeepers
- Other
  (Expenditures also)

Unpaid Labor and Salaried Labor with Ownership Claims

There are a number of alternative measures that could be used to estimate the cost of unpaid labor and salaried labor with ownership claims. These include (1) the marginal value of farm labor obtained via shadow values from programming models, or value of the marginal product from econometric models; (2) wage rates of farm managers and/or hired farm labor; (3) off-farm wage rates of farm people; and (4) off-farm wage rates of nonfarm people who have similar human capital characteristics as unpaid farm labor.

The most insightful approach to considering the economic cost of unpaid farm labor and salaried labor with ownership claims is from the perspective of "opportunity cost."

Alternative 1

The cost of a unit of unpaid (or family) farm labor in one enterprise can frequently be measured as its value in another farming enterprise. This approach, however, is strictly appropriate only if the farm value exceeds the value in nonfarm uses (e.g., nonfarm employment, leisure, or home production). The value of labor in a particular farming enterprise is generally determined by a number of other farm decisions, such as the quantity of accompanying inputs and type of technology used. Thus, a value of farm labor determined internally to the farm business is frequently of suspect quality and a weak measure of the costs of farm labor. Farm operators who are very successful will have a marginal value of time in farming that exceeds by a large margin their implicit wage for off-farm work. When we use the implicit off-farm wage as the price of these successful operators' time for agriculture, the "quasi rents" that their farming skills are earning will appear as part of the returns aggregated together in the "residual" farm return category.

Alternative 2

For unpaid farm labor, the wage rate of professional farm managers is sometimes used to approximate the (replacement) cost of the hours used by a farm operator in decision making, and the wage rate of hired farm labor is used as the cost of all other unpaid farm labor. Although this approach has the frequent advantage of being fairly easy to apply, there are some problems with the economics of the approach. First, a farm operator's labor cannot generally be divided easily into decision making hours and other farm work hours. Much of his or her farm labor produces a joint product of "field work" and decisions. Attributing the wage rate of professional farm managers or hired farm laborers to field work performed by the farm operator independent of his/her off-farm opportunity cost may lead to errors in calculating the true cost of the field work. Second, the quality of decision making by farmers and professional farm managers may be quite different. Third, the human capital investment in schooling and useful experience of farm operators is generally much larger than that of hired workers; so when they are working at the same task, farm operators are generally more productive. Fourth, farm operators (and unpaid family members) have stronger incentives for getting farm work done in a careful and timely fashion than do hired nonfamily members. The primary reason is that farm family members can expect to share directly or indirectly in net farm income, but hired nonfamily farm labor generally does not.[2] If these differences in skills and incentives are important, it is also essential that the hours utilized (required) for specific tasks or enterprises be adjusted to reflect this difference in productivity. Given the difficulties in attributing wages of farm managers and/or unskilled workers to unpaid family labor in a way that is consistent with tasks performed, incentives, and relative productivity, this method is probably only appropriate when no other estimates exist. The farm labor

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[2]Performance-based incentive plans for hired labor are sometimes used to strengthen the incentives for hired labor to complete farming activities in a timely fashion. These plans can make a dramatic difference in performance, but they are generally imperfect.

of children of farm operators frequently may be approximated well by the wage rate for similarly skilled hired farm labor.

Alternative 3

Off-farm wage rates of farm people contain valuable information about wage opportunities of similarly skilled and located individuals who do not work off-farm. This method views off-farm work as the best alternative to farm work. In order to add precision to the process of valuing characteristics of individuals and localities, hedonic wage regression equations could be fitted to a national sample of off-farm work participants. Furthermore, the results are most useful if there is a significant number of farm operators working off-farm in each state. An example of this approach is the work by El-Osta and Ahearn.

A major advantage of this approach is that it uses labor market information to value personal and locational characteristics, which are generally more objective than other values. This approach does not assume that all farm labor has the same skills or productivity in farm work, or that they have the same opportunities in off-farm work. Upper-aged farm operators, having no prior off-farm work experience, may not have "good" off-farm work opportunities. For farm households located in sparsely populated areas, a locally thin labor market may exist for some skills. If individuals in these areas are going to consider off-farm work as their best alternative, they might need to move to another geographical location. Some individuals/households in all locations are always operating at this margin, (i.e., considering switching to part- or full-time off-farm work) so this prospect is not too dramatic. This fitted wage equation could be used to predict off-farm wage rates by state for farm operators.

Alternative 4

Off-farm wage rates of nonfarm people also contain much information about the value of human characteristics as assessed by the labor market. In principle, all individuals, irrespective of their residence and skills, are being evaluated by the same general market forces because there is arbitrage across geographic locations and skills (Rosen 1986; Tokle and Huffman). Nonfarm individuals might have significantly different characteristics from farm people. Existing evidence suggests that the primary difference is the quality of a year of postschooling experience. At any age, a year of postschooling experience of farm people is worth less in the nonfarm labor market than a year of nonfarm work experience of nonfarm people. Thus, although hedonic wage equations fitted to a sample of nonfarmers contain much useful information about the implicit market price of personal and local characteristics, they should be interpreted with some care. A more specific discussion of the implementation of alternatives 3 and 4 is contained in the next section.

> ***Although each of the alternatives has certain merits for specific situations, the Task Force recommends that for unpaid farm labor (and salaried labor with ownership claims), the cost for all operators, partners, and spouses, who are adults, should in most cases be the market wage (or compensation) per hour for nonfarm work. The preferred method to estimate this is alternative 3, but alternative 4 is also acceptable,***

particularly when off-farm wage information is not available for farm people. For children in farm households, the Task Force recommends that their farm labor be valued at the wage rate for hired farm labor if they are 16 years of age or older and be set at the local minimum wage if they are less than age 16. If the children are obviously more skilled than (nonfamily) hired labor, then a higher wage should be used such as the amount a neighbor would pay them for similar work.

Nonfarm employment is the primary cash-earning alternative activity to farm work for most individuals. Nationwide almost 50% of U.S. farm operators and spouses participate in off-farm work sometime during a year (U.S. Dept. of Commerce–Census of Agriculture). When unpaid farm laborers make a decision on whether to continue with farm work or seek nonfarm employment, they generally weigh their earning prospects in nonfarm employment against those in farming. Thus, the most important aspect of the off-farm wage used to approximate the opportunity cost of farm labor is that it pertains to labor containing similar useful characteristics (e.g., schooling, experience, location, and time of availability). Variables such as gender and race are often included in such regressions because they seem to capture information (proxy) that is not otherwise reflected in imperfect quantitative measures of human capital characteristics included in the model.[3]

HEDONIC WAGE EQUATIONS FOR ESTIMATING LABOR COSTS

On a national basis, the most reliable means of implementing opportunity cost valuation of farm labor is by using predictions from econometrically fitted wage or labor demand equations. The concept of equalizing differentials due to employee and job (or employer) attributes (see Elliott: 313; Rosen, 1986) has been given empirical content through hedonic wage or labor demand equations for labor services of individuals holding particular jobs. The hedonic or characteristic approach to explaining or determining the wage (or price of a good or service) is based upon the empirical hypothesis that asserts that the multitude of skills or attributes of workers and jobs (or models and varieties of a particular commodity) can be comprehended in terms of a small number of characteristics or basic attributes (Griliches: 4; Rosen, 1974). By viewing the problem in this way, the magnitude of the number of truly different types of labor services, jobs, or submarkets available is greatly reduced because "new ones" are just viewed as a new combination of "basic" attributes that have been present for some time.

In its parametric, or wage equation, version, the methodology asserts the existence of a reasonably good fitting empirical relationship between the hourly wage and an employee's skill and the employer's various but not too numerous attributes. Labor economists have accumulated a large amount of evidence about (1) the relevant set of basic attributes for employees and jobs, (2) the algebraic form of the relationship between

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[3]Wage differences not explained by a hedonic model may well reflect discrimination or other factors that are not associated with past, present, or future productivity of labor. The value of using a properly specified hedonic regression model is that on the average these errors will have a mean of zero and be uncorrelated with the included variables.

the wage and attributes, and (3) special problems of sample selectivity or nonrepresentativeness of actual workforce participants relative to the population of potential participants (Pencavel). The relationship can be summarized as

$$ln\ W = ß_o + X_1ß_1 + X_2ß_2 + d_3? + \mu \quad \textbf{(8.1)}$$

where W is the average (hourly) wage, X_1 is a vector of personal attributes of the worker that are exogenous to current workforce participation decisions (e.g., age, years of formal schooling, years of potential or actual postschool workforce experience, etc.), X_2 is a vector of job or employer associated attributes that are exogenous to current workforce participation decisions (e.g., geographical location of work, anticipated and unanticipated local labor market conditions, local cost of living indicators, and indicators of local amenities), and ? is a function of the probability of an individual being employed in wage work. The variable ? controls for sample selectivity of workforce participants from the pool of all potential workforce participants. The disturbance term µ is a random zero mean variable that represents the impact of many other factors that affect wage rates, but that are individually of minor importance to the wage or labor demand facing an individual.

The hedonic wage equation (8.1) is a type of reduced-form equation, and its parameters (ßs) need not be constant over time, regions, broad industrial categories, or classes of workers. Empirical studies by labor economists, however, have shown considerable stability over time and across similar, but not exactly the same, individuals. The evidence does suggest, however, at least for the nonfarm population, that wage equations for men and women usually differ by more than the constant term. The primary reason for this is greater within-gender homogeneity of particular attributes than across-gender homogeneity (Gunderson; Rosen, 1986; Willis; Goldin; Smith and Ward, 1984, 1989; Fuchs; Juster and Stafford; Pencavel; and Killingsworth and Heckman). Given that only about 7.5% of all farm operators identified in the 1992 Census of Agriculture were women, however, the analyst must weigh the potential for increased accuracy from separate equations with the reduced precision of a smaller sample size.

An important consideration in estimating wage equations for members of farm households is the joint aspect of the labor force participation decision. The farm operator and/or the spouse may choose to work full or part-time off the farm or to work only in the farming operation. Since farm and nonfarm family income is usually lumped together in making consumption decisions, the joint aspects of this decision to work may affect the estimated value for ? in equation 8.1 (Huffman and Lange).

The size and density of labor markets may matter in valuing farm labor. When some of the prospective workers and some of the jobs are tied to specific geographical areas, aspects of local labor markets matter for labor market outcomes. For example, members of farm families tend to be tied to particular parcels of land, married adults are largely tied to each other, and jobs are tied to particular geoclimatic aspects of the local environment or distance from large centers of consumption. Kenny and Denslow, Adams, Topel, Tokle and Huffman, and others have found geographic boundaries defined by states to be adequate representations of local labor markets in the United States. For large states like Texas and California and some others on the border of the contiguous 48 states, such as Minnesota, Wisconsin, Michigan, and New York, it might be important to separate the state into two or possibly three labor market regions.

Fixed employment-related costs and density of demand for particular skills, frequently referred to as the size of the market, also have major impacts on the distribution of skills available in the labor market and the overall functioning of the labor market. Adam Smith (1776 and reprinted 1937) noted more than 200 years ago that the extent of specialization that can be achieved (obtained or supported) in a market is proportional to the size of the market (Stigler, 1951, 1962; Rosen 1983; Becker). Thus, only very large labor markets or urbanized areas can support extremely specialized human capital (specialized accountants, tax preparers, lawyers, and medical doctors are a few examples). The reason is the very large investment in skill that is required relative to the size of the demand by any one household, firm, or individual for these services (Rosen 1983). Modern communications and microcomputer systems have extended the accessibility of rural areas to some of these services.

In rural and some other areas where people are tied to particular places due to the location of farm land, family relationships, and fixed costs, and where other transaction costs are high, employees' skills (men and women) and jobs are likely to be less perfectly matched than in urban areas, which can lead to employees being overqualified for the jobs that they hold. The relative degree of the mismatch and the frequency of significant mismatches are likely to be larger in rural areas and small towns than in large urban areas. The outcome of this mismatch is subject to several different interpretations. The issue of thin rural labor markets is a research topic that Briggs (1981, 1986) has examined. In some areas of the United States, especially in the Great Plains and Mountain States, low density of people and jobs and high transaction costs seem likely to reduce the efficiency of the functioning of rural labor markets.

As an example of wage or labor demand equations fitted to a large sample of individuals drawn from the farm population, consider the United States Department of Agriculture (USDA) publication by El-Osta and Ahearn. The study considers the off-farm work activities of individuals from selected farm households. The regressors in these equations are variables for individual characteristics as well as characteristics of the state in which the individual resides. Using this information on characteristics, the equations can be used to predict an individual's wage for nonfarm work.

As a practical matter, wage equations would not need to be fitted every year to data in order to obtain good forecasts of off-farm wage rates. Real wage rates for particular attributes are relatively stable over time, except for trend. Better wage equations can be obtained by pooling data together for individuals in the 48 contiguous states than by fitting equations to observations for each state separately. Most likely, wage equations would need to be fitted at least once in five years. A more complete discussion of some of the issues involved in measuring the costs of farm labor is contained in Huffman (1996).

A joint Economic Research Service-State Agricultural Experiment Stations (ERS-SAES) venture in production of new farm labor cost data could contribute significantly towards obtaining this information. This venture could take the form of a small committee to set methods and oversight consisting primarily of USDA and SAES researchers. The USDA, however, appears to have a large advantage in carrying out the procedures and distributing information to all interested clientele.

CONCLUSION

Farm labor was defined as labor and related services. Furthermore, it was recommended that all of this class of inputs be treated similarly in CAR analysis. Farmers should be surveyed for their estimate of the annual amount of labor used on their farm. As needed, they should be asked to allocate the time among the commodities that they produce. In the long term, it would be desirable for cost of production estimates to move away from such subjective methods for allocating labor to particular commodities. This could possibly be achieved by using econometric estimates of cost or profit functions for multicommodity technology.

The chapter contains several recommendations for valuing farm labor in CAR analyses. The recommended approach for hired labor (with no farm ownership claims) is to value labor at producers' cost. Specifically, hired labor with no ownership claims should be valued at the wage rate (plus fringe and other benefits) for contract farm labor. All adult unpaid farm labor (and salaried labor with ownership claims) should be valued at its opportunity cost, defined to be the maximum value for nonfarm uses. Hedonic wage equations are the suggested method for estimating these values. The preferred alternative (3) is to estimate these equations based on the off-farm wage rates of farm people. An acceptable alternative (4) is to obtain estimates based on the off-farm wage rates of nonfarm people who have similar human capital characteristics as unpaid farm labor. Equations based on alternative 3 can be estimated using data available from the USDA's national farm household surveys (El-Osta and Ahearn). Except for children employed on the farm, wages and salaries paid to spouses of operators, partners, and shareholders for farm work should not be used in cost of production estimates. These wages are unlikely to be closely related to the opportunity cost of labor provided by these individuals since the determination of these salaries is usually arbitrary.

CHAPTER 9

JOINT COSTS, GENERAL FARM OVERHEAD, AND RIGHTS TO PRODUCE

JOINT COSTS

Definitions

Joint production costs have been defined in the economic literature as costs that "are incurred on groups of products rather than on individual and separate ones" (Hopkins and Taylor: 404). At least three different situations give rise to joint costs. These include (1) expenses incurred in the production of joint products (defined as technically interdependent commodities arising from a joint technology), (2) expenses for inputs that affect the production of more than one enterprise (independent but organizationally related commodities) even if the production technologies are non-joint, and (3) outlays for production inputs that are either purchased for the farm as a whole or are used for the entire set of production activities undertaken by the farm. The second category is best exemplified by the allocation of capital inputs (and/or their services) or fixed expendable inputs to different enterprises. For example, the total amount of fertilizer applied by the firm is usually divided among several different crops. Or the total number of tractor hours is divided between crop and livestock operations. The third category is usually referred to as general farm or business overhead and typically includes items for which it is difficult or impossible to determine the impact of the input on either output or cost for a specific enterprise. For example, it is difficult to determine the impact of buying a new set of Allen wrenches on the average corn yield per acre or the impact of attending pesticide applicator training on cucumber gross returns. Each of the three situations may give rise to joint costs that occur either as direct costs or as indirect costs. *Direct costs* are defined as those costs that can *normally be associated with a specific enterprise* though not necessarily with individual products generated by the enterprise. *Indirect costs* are those costs which may apply to *several enterprises or production cycles*. Some inputs such as fertilizer or lime, which are normally viewed as direct costs to a given enterprise, may have an intertemporal or residual carry-over dimension that may affect the production of multiple enterprises. Individual expendable and capital inputs may fall in either or both of the direct and indirect cost categories.

Overview of Issues

The three situations identified above involve the sharing of resources either among various enterprises or among unique products generated by a single enterprise. As has been well documented in the literature, the allocation of shared resources and their associated costs among products makes the process of developing a separate cost estimate for individual products highly complicated (Gilliam; Boulding). In fact, Hopkins and Taylor wrote in their 1935 treatise on “Cost of Production in Agriculture” that "The nature of joint costs...dooms any effort at their apportionment” (Hopkins and Taylor: 404). Nevertheless, a variety of computational methods has been used to allocate joint costs in order to provide cost and return (CAR) estimates for specific products. These estimates may be needed for use in a variety of purposes ranging from farm management to applied commodity program analyses.

Chapter 9. Joint Costs, General Farm Overhead, and Rights to Produce

PRODUCTION COSTS FOR JOINT TECHNOLOGIES AND ALLOCATED COSTS OF PRODUCTION FOR NON-JOINT TECHNOLOGIES

Enterprises were defined in Chapter 2 as any coherent portion of the general input-output structure of the farm business that can be separated out and analyzed as a distinct entity. The purpose of defining enterprises is to allow analysis of that enterprise. The most common enterprise definitions involve one output and the inputs used to produce that output as is the case with non-joint technologies. Note, however, that the multiple outputs produced with a given technology may be spatially or intertemporally differentiated forms of the same product rather than distinct outputs. Such outputs must usually be handled in a joint product framework rather than as non-joint products and the input allocation methods used must account for these spatial and time differences. Enterprise CAR estimates allow a static analysis of that enterprise for a point in time that involves one production period. Because of this static analysis, an enterprise CAR estimate will only be valid if the enterprise is in a stable or nongrowth mode. Crop enterprises should not reflect levels of fertilizer application which tend to "warehouse" nutrients, nor should they reflect resource "mining." Livestock enterprises should show a culling rate that only will maintain herd size and not reflect growth or entrenchment.

In the case of non-joint technologies, inputs and their associated costs are tied directly to an individual enterprise and may not require any procedure for allocation. The most common problems arise with inputs that are purchased on a whole-farm basis and where records are not available on allocations of these inputs to individual operations. Common examples of allocated inputs include family labor, machine time, multipurpose buildings, and sometimes fertilizer or agricultural chemicals. It is important in estimating these costs that the sum of the allocated costs add up to the total costs for the whole farm or operation.

Even when the technology is inherently joint, as in the case of corn and soybeans in rotation, it is often possible to accurately allocate specific inputs to one crop or the other as would be the case with seed. However, those production inputs that affect multiple enterprises in a complex way should be allocated to the appropriate enterprise according to the marginal factor costs associated with each respective enterprise. The allocation of fertilizer expense in the case of a corn-soybean rotation is a good example of where the allocation is not completely straightforward. The allocation of pasture costs to a calf and to a cull cow is rather arbitrary and in determining the cost of feed used to maintain a ewe for one year, the allocation of costs between the production of wool and the production of a feeder lamb is ludicrous.

Costs that require allocation to more than one enterprise due to residual or secondary value (intertemporally) to the second enterprise can include both expendable inputs and certain capital or durable inputs. Expendable inputs should be used in an enterprise at the level required by that enterprise to maintain the specified level of production. Any amount of unused input which results in a residual benefit to a second enterprise should be reflected as a cost to that second enterprise and a reduction of cost to the first enterprise. Again, enterprise CAR estimates should reflect only sustaining levels of input use.

Two situations exist in terms of the benefits of an input to more than one enterprise. The first is where full expected benefits have accrued to the first enterprise but residual benefits will also accrue to the second enterprise. An example would be planting alfalfa on land which will be followed by a nitrogen-using crop that benefits from the nitrogen-fixing characteristics of alfalfa. The second is where both enterprises benefit from use of the input, but this use is not mainly associated with one enterprise. An example would be fencing that exists between a pasture used for cattle and a wheat field from which cattle are to be restricted.

In the first situation there is an advantage to the crop that follows alfalfa but only to the point at which the additional nutrients available are mined by the following crop. That residual value will disappear if not used by the second crop. The appropriate value to be used for the residual benefit (in this case nitrogen) is the opportunity cost of acquiring that benefit from the next best available means of obtaining it.

In the second situation both enterprises benefit from the input and its cost should be allocated based on the value to each enterprise. In the example, there is no question that both enterprises benefit, but the benefit to the wheat decreases if it were not next to the pasture, and in a totally wheat area, the value could become negative due to the need to maintain fence areas where they would not be otherwise necessary.

Jointly used inputs can be allocated to separate enterprises by several methods. The allocation process can be based on use as determined by acres, hours, dollars, times over, number of units, or some other appropriate measure of use. Values should reflect the marginal factor cost of the input to that particular enterprise. The cost can be based on either opportunity cost or market cost methods. Opportunity cost should reflect the value of that portion of the input used by the enterprise in its "next best" use. Market cost should reflect the value of the portion of the input used if the input were purchased for use on the market.

Allocating the costs of such expendable cost items as fertilizer, chemicals, fuel, lubricants, and repairs for machinery can be accomplished fairly directly based on the use of these inputs by the individual enterprises. Allocation of costs such as depreciation of equipment or land rent also can be done using procedures that have been generally accepted such as hours of use or acres planted, though there may need to be some "fine-tuning" of these processes. For some assets it is difficult to develop an acceptable allocation procedure—for example, fencing between oats and bermuda pasture grazed by cattle. Are the cattle being kept in the bermuda pasture or are they being kept out of the oats? Each situation needs to be analyzed according to the area. If it is generally a pasture area, then the cost of the additional fencing for the oats should be charged to the oats, but if the area is generally tilled, then the charge for the additional fencing should be charged to the bermuda pasture. In other words, the generally accepted practices of the area must be considered in allocating such costs.

In summary, most production costs for non-joint technologies can be allocated to an enterprise, if the enterprise is considered to be in a sustaining position. This reduces the effect of warehousing or mining by the enterprise. If inputs are applied for use by a second enterprise, the marginal factor cost of the input should be charged to that second enterprise and not to the first enterprise. Machinery and equipment inputs have well-defined processes (i.e., acre-trips, machine hours, etc.) for the allocation of their costs across enterprises.

The Task Force recommends that costs of production for joint technologies be estimated for the technology as a whole allowing for multiple outputs in the enterprise definition. In cases where there is a need to estimate costs for individual outputs such as for corn and soybeans in rotation, the Task Force recommends that costs be allocated on an objective basis involving information on input allocations and input levels that neither warehouse or mine inputs.

In the case of non-joint technologies, the Task Force recommends that the costs of inputs be allocated based on objective data on individual enterprise use. The Task Force recommends the use of data on land allocations, hours of use, acre-trips, pounds applied, etc., to determine these allocations. If objective data on the allocation of inputs between enterprises is not available, the costs of these inputs <u>should be excluded</u>, <u>should remain unallocated</u>, <u>or in rare instances allocated following the guidelines</u> pertaining to general farm overhead expenses.

GENERAL FARM OVERHEAD EXPENSES

General overhead costs associated with operating a business are usually incurred at the total farm level, across all enterprises, although in some instances these costs can be assigned to groups of products. Examples include liability insurance, subscriptions and dues, accounting and legal fees, shop tools, equipment storage, road maintenance, and so forth. Allocation of these shared costs to individual enterprises is often difficult or impossible in anything but an arbitrary manner. Managers, however, often must make decisions on individual enterprises, based on CARs for producing those enterprises. In such situations, it may become necessary to use some procedure that allocates overhead costs across the appropriate enterprises. Several methods have been developed that are somewhat effective in this task. These methods are based on information from surveys or from mathematically described algorithms that approximate their impact on the enterprises.

A wide variety of methods are used in practice to account for and allocate overhead expenses. Evidence suggests that approximately 75% of the CAR estimates prepared by economists at land grant universities include an estimate of property taxes on land or equipment, and approximately 90% include charges for property insurance. Almost without exception, an opportunity interest on operating capital is included. Only about one-half of the states include business overhead costs such as office expenses or attorney fees in their CAR estimates (Klonsky, 1992: 150). The United States Department of Agriculture (USDA) includes an estimate of taxes and insurance on machinery and real estate used in production as well as an estimate of general farm overhead expenses. The USDA's general overhead cost category includes expenses to purchase such items as general farm utilities (as opposed to utility expenses for practices such as drying or irrigation that are attributable to a specific enterprise), farm shop and office equipment, supplies, drainage, accounting and legal fees, road and fence maintenance, business travel, dues, and membership fees. The USDA also includes interest expenses incurred on both operating loans and loans secured by real estate.

When overhead costs have been included in CAR estimates, a variety of methods has been used to allocate them to specific enterprises. The more common allocation methods are presented below. Most of the methods that have been used imply that the overhead costs included in CAR estimates have been derived from observed whole-farm revenue and expense data. In practice, however, this may not have been the case for, as Klonsky observed, "Fixed operating costs are sometimes collected from farmer surveys. Alternatively, they are estimated as a percent of variable operating costs or as a percentage of the value of equipment" (Klonsky, 1992: 152). Given the variety of expense items that have been included in estimates of overhead costs along with the large number of methods used to prorate these costs among commodities, it is to be expected that the allocation of indirect expenses is viewed as a difficult and highly contested aspect of CAR estimation (Klonsky, 1989).

Economics of the firm indicates that the profit-maximizing amount to produce of any one commodity is found by substituting among enterprises until the marginal rate of product substitution equals the inverse ratio of net revenues (Boehlje and Eidman). Or, stated differently, the firm is "to be regarded as seeking to maximize the difference between expected receipts and variable costs" (Friedman: 109). This decision rule maximizes net returns to the limited resources. Thus, the choice of which and how much of an enterprise to produce depends on the enterprise's relative contribution to these fixed factors of production. Consideration of fixed general farm overhead or fixed cash expenses is not relevant in arriving at management decisions related to types or optimum amounts of an enterprise to produce (Miller and Skold). Instead, the net revenues from enterprises produced by the firm are available to cover these fixed expenses.

Overhead expenses (once incurred) have no effect on enterprise selection or production decisions, and any method chosen to prorate these expenses to a specific enterprise is usually arbitrary.

The Task Force generally recommends <u>excluding</u> estimates of general overhead expenses from enterprise CAR estimates when those costs cannot be allocated on an objective basis. When allocation is necessary to compute the total costs of production for a specific enterprise, however, the method chosen should be enterprise neutral; i.e., enterprise selection or production decisions made after this allocation coincide with those made before the allocation. This recommendation has the effect of minimizing the impacts of tenure and use of debt capital on estimates of enterprise costs.

It is recognized that general farm overhead and other allocated overhead cost items such as machinery depreciation or establishment costs of multiyear enterprises are important considerations in establishing cash flow estimates for farm businesses. Nonpayment of these costs, particularly taxes and interest, would result in the firm's being in default. Thus, the CAR estimator may want to provide additional information to help data users better interpret cost and return data for their purposes. For example, data showing the combinations of enterprises produced and the degree of specialization of farms in conjunction with data showing how general overhead and fixed payments vary would help the data user better understand a farm's ability to meet both its cash and noncash obligations.

COMMONLY USED METHODS FOR ALLOCATING JOINT COSTS

Methods used to allocate expenses among products, or spatially or intertemporally on a given product, depend greatly on other management information used on the farm. If a farmer keeps detailed records of the use of various farm resources, those records will likely form a good basis for allocation. However, these types of records are usually not kept, so other allocation indicators must be used. Following is a description of some of the costs that are commonly allocated among enterprises, what measures are best suited for each type cost, and their limitations. Joint and non-joint technologies are considered along with general farm overhead items. Some of these costs may not require allocation, as they are often calculated directly for the respective enterprise. For example, land rent and machinery costs are frequently directly attributable to specific enterprises.

Land

The cost of land usually includes rents, property taxes, opportunity cost of owned land, and any maintenance required to sustain the productivity of the land such as terracing, soil additives, and covers. The allocation of land cost across enterprises is usually straightforward; i.e., it is divided across enterprises on the basis of how much land each enterprise uses. In some instances, land cost may take on different values depending on the quality of the land and its use. For example, land in permanent pasture or in a cattle feedlot likely has a different value from land in constant tillage or planted to trees. Therefore, allocation of land cost may be a multiple stage process—first allocating total farmland cost among the major categories of land, then allocating each category among those enterprises using each category. Associated with access to land, buildings, and corrals are roads and alleyways. The costs of the land required and annual maintenance for these should be allocated based on the percentage of use by each enterprise. For example, the cost of maintaining a road between the feed bins and the cattle corral should be charged primarily to the cattle enterprise even though it may be used to get to one of the sorghum fields. Chapter 7 contains a more detailed discussion of issues related to the estimation of the costs of land.

Machinery

Machinery costs include capital recovery of machinery investment, fuel, lubricants, and repairs. Where machinery items are enterprise specific (e.g., cotton strippers, grain buggies, peanut diggers, or hay balers), related machinery costs can be allocated to the respective enterprises. However, most farm machinery, particularly tractors, is used across multiple enterprises. A commonly used method of allocating these costs is acre-trips. That is, for each enterprise, multiply the number of machinery practices used by the number of acres in the enterprise—then allocate across enterprises using each enterprise's portion of total acre-trips on the farm. One problem that arises using this method is that it assumes all tillage practices are equal in cost. Enterprises that utilize only light tillage, therefore, are allocated a disproportionately high machinery cost relative to enterprises that use heavy tillage. Another method that somewhat addresses this problem is to allocate on the basis of custom rates or machinery costs calculated using agricultural engineering models. Using this method, each tillage practice for an enterprise is initially expensed using these cost proxies. The actual total farm machinery expenses are then allocated using each enterprise's share of total calculated or custom rate expense. As discussed in Chapters 5 and 6, the operating and capital costs of most machines can be estimated on an hour of use basis. These costs are then appropriately allocated to alternative enterprises based on hours of use (heavy tillage requires more hours) for the tillage operations associated with the enterprise.

One common expense that is difficult to allocate is the cost of owning and operating a pickup truck that is used for a large number of enterprises. The most important determination is the proportion of the usage that is associated with the farm business as opposed to personal use. Allocation of the business use across enterprises is best done by producer survey or expert opinion. The alternative is to allocate use based on revenue proportions as is sometimes done with general farm overhead expenses.

Property Taxes

Property taxes should be allocated on the same basis used to allocate the use of the property itself. That is, property taxes on land are allocated using the land allocation method, while property taxes on farm buildings and equipment are allocated according to the buildings and equipment methods. Property taxes on residences should not be allocated to enterprises at all except to the extent that a portion of the residence is used as a farm office.

Buildings and Improvements

To the extent that buildings and improvements are designed specifically for use by certain enterprises (e.g., swine farrowing facilities, grain bins, and hay storage barns), costs of depreciation, interest, and maintenance of these items should accrue to the enterprises affected. Costs of buildings used to house or repair machinery should be allocated on the same basis as the costs of machinery which utilize these facilities. For example if the tractors take 1/3 of the space in the storage shed and the dry bean enterprise takes 2/5 of the tractor time during the year then the dry bean enterprise could be assigned 2/15 of the cost of the shed for tractor storage time. The beans would also need to be assigned a cost for the space taken up by the planter, the harvester, and so forth that they use. For other nonspecific buildings and improvements, the costs should be allocated as discussed in the subsection on general farm overhead.

Insurance

The method of allocation depends on what type of insurance is being purchased. Property insurance should be allocated on the same basis as is used for the respective property itself. Crop insurance accrues to the respective crops. Health insurance should be allocated using the same basis as is used for labor. Other general farm insurance such as liability insurance can be treated as general farm overhead and allocated as described in a later section.

Utilities

Unless utilities are metered separately for different enterprises, some allocation procedure is required. This allocation usually requires some judgment on the part of the farmer, as it is difficult to use any other cost indicator. One possibility for electricity is to estimate the total motor horsepower or total wattage used by the different enterprises and allocate on that basis. However, given the variability in use, this method is questionable. Without any objective basis for utility allocation, utility expense should be allocated as described later for general farm overhead.

Labor

Allocation of labor depends on how the labor is used. Any labor cost associated with operating or maintaining machinery should be allocated using the same basis used in allocating machinery costs. Other labor, if specific to an enterprise, should accrue to the respective enterprise. Otherwise, any other non-enterprise-specific labor should be treated as general farm overhead. Chapter 8 discusses issues related to the estimation and allocation of labor services.

Management

Chapter 9. Joint Costs, General Farm Overhead, and Rights to Produce

Generally, management cannot be separated from labor, and any allocation of management costs follows that of labor discussed previously. However, where farms incur management fees, a commonly used method is to allocate those fees on the basis of gross income. This creates a problem in that gross income does not often reflect where management is actually devoting its effort. Overall market prices or weather may drive gross income up or down for any given enterprise with no change in what management has done for that enterprise. For example, although 75% of a manager's effort may be devoted to managing one enterprise, favorable weather may have helped a second enterprise to generate 75% of the gross income. A recommended alternative is to allocate management costs on the basis of other allocated costs. It can be argued that managers manage other input resources. Therefore, if an enterprise requires 75% of the other input resources, the manager is more likely to devote 75% of his/her effort to that enterprise than to a second enterprise which may have generated 75% of gross revenue. Chapter 8 discusses issues related to the estimation of labor costs, particularly as they relate to the valuation of operator whether in performing routine technical or decision making functions.

General Farm Overhead

There are some general farm overhead expenses that typically have no reasonably objective method of allocation based on information available to the producer. Subscriptions, dues, accounting and legal fees, business travel and training, general farm liability insurance, and otherwise nonallocated labor, utilities, insurance, buildings and improvements generally fall into this category. Several methods could be used to allocate these costs, but economists often argue that because these costs are not affected by enterprise selection or management, any allocation of these costs should be enterprise neutral. One method that has often been used is to allocate these expenses on the basis of gross value of farm production. An alternative method is to allocate general farm overhead on the basis of other allocated costs. Both of these methods, however, can lead to distortions in enterprise selection and management, as gross enterprise margins (gross income less allocated costs) are impacted disproportionately.

> ***The Task Force recommends when an objective method to allocate general farm overhead is not available the allocation be based on enterprise gross margins. In this way, enterprises are impacted relative to their importance to overall farm profit, and decisions about enterprise selection and management are neutral to general farm overhead expenses.***

However, in the instance where an enterprise has a negative margin, this method creates a mathematical problem. In this case, it is recommended that the allocation be made on the basis of long-run expected gross margins or on the basis of other allocated costs.

> ***When including estimates of general farm overhead, the Task Force recommends that CAR estimates include a separate estimate document for the general farm overhead expenses. From this estimate, allocations would then be made to each of the enterprises on the farm.***

In making the allocations, the format in Table 9.1 is recommended. This format accomplishes much the same as Schedules 14.6-14.8 of the dairy farm example included in Chapter 14 of this report. The items included in the table are those thought to be general farm overhead expenses, are not easily allocated using objective methods, and are recommended for inclusion in the CAR overhead estimate. As indicated in the footnotes to the table, it is suggested that a different allocation method may be applicable for each type of overhead expense, and that the allocation be made on a line-by-line basis. After all overhead expenses are allocated, the totals allocated for each enterprise are then entered into the respective CAR estimates for those enterprises as a single line item input titled "Allocated Overhead." A table similar to Table 9.1 could also be constructed to assist in documenting the allocation of joint costs to enterprises on an objective basis. Such a table might include lines for land, operator labor, family labor, hired labor, tractor time, combine time, irrigation water, fence repair, and so forth. Such a table helps ensure that the sum of enterprise use and cost adds to total use and cost, that all costs are accounted for, and may help the analyst in checking the estimates for consistency with other objective data.

TABLE 9.1 Allocation of Overhead in CAR Estimates

Overhead Item	Whole-Farm	Enterprise 1	Enterprise 2	Enterprise n
Accounting/legal fees				
Advertising				
Computer & related office equipment (annualized costs)				
Education				
Farm office				
Farm organization dues/meetings				
Farm shop (portions could be included in repair cost estimates)				
General use vehicles (farm share)				
Maintenance of general farm facilities				
Property/casualty insurance				
Publications				
Umbrella liability insurance				
Utilities/phone				
TOTAL	Total Farm	Tot. Ent. 1	Tot. Ent. 2	Tot. Ent. n

Note:
(1) Each line in this worksheet is allocated separately.
(2) The total for each enterprise is transferred as a single line item input into the respective enterprises.

RIGHTS TO PRODUCE

Definition

Rights to produce pertain to *incidents of ownership* of resources used in production, the impact of *regulations* governing the use of those resources, *access to markets* for the commodities produced, and *access to enhanced prices or other incentives* associated with market access. These rights generally involve payment of rent, royalties, increased production costs, or foregone production in exchange for benefits of enhanced production or markets.

Overview of Issues

The costs of producing agricultural commodities arise not only from the purchase of production inputs but also from gaining access to resources and markets. In some instances, gaining access comes at additional cost of other inputs. In other instances, gaining access requires payment of a royalty to property right owners. Following is a brief description of the issues concerning rights to produce.

Ownership of Resources

Some resources essential in producing an agricultural commodity are not separately available for purchase in an open market, but are attached to, or a part of, other "host" resources. For example, grazing rights and water rights are often associated with land ownership. Therefore, unless a producer owns the host resource, he/she cannot own the secondary resource. That producer, however, can still access the secondary resource by compensating its owner through the payment of rents, royalties, or easements. At issue is whether, and how, to account for costs of access to these resources.

Regulations on Use of Resources

The use of resources is coming under closer public scrutiny, particularly when that use may lead to degraded water quality, erosion, or other off-farm impacts. Many states have passed laws that govern dairy waste management, for example, which dictate how dairy farmers can operate. These farmers can either pay the cost of complying with the regulations or quit producing milk. Use of certain pesticides has been severely curtailed, often resulting in offsetting costs of other inputs, or degraded productivity. Denying farmers the use of wetlands on their farms may result in degraded productivity. The question here concerns the degree to which such regulations impact costs of production, how those costs can be identified, and whether these costs are capitalized into the cost of other resources.

Access to Markets

Generally, farmers can find a market for almost anything they produce; at least they are not technically prohibited from producing and selling most commodities. However, the marketing of many commodities in the United States such as fruits, vegetables, and nuts is controlled through such techniques as market orders, organic certification, or other quota systems. These market orders usually dictate quality standards and assure the orderly flow of commodities to markets. However, these orders may also be used to control production levels through the use of market quotas. Without a quota, or without the ability to produce the quality of commodity dictated by the quota, the farmer has no market. What is the cost of acquiring quotas and what must be given up to produce for the quota (e.g., costs of quality-enhancing inputs) are two questions of market access that must be considered.

Access to Market Enhancements

Many programs exist that provide incentives to farmers who pay the price of participation. Market orders may assure higher, more stable prices for their respective commodities, but require compliance with timing and quality standards. Certain government programs, such as the peanut program, provide support prices for "quota" peanuts, with the rest of the peanuts being sold as "additional peanuts" receiving a significantly lower price. Other government programs offer deficiency payments and access to the Commodity Credit Corporation (CCC) loan programs in exchange for establishing a crop acreage base, idling land, and conserving soil resources. The question arises as to how these costs should be determined, and what are their associated market enhancements.

Estimation Procedures

Costs of rights to produce involve two major components—**costs of acquiring the right and costs of exercising the right**. In any CAR estimate where rights to produce are involved, it is important to define clearly these two types of costs **and to include in returns the benefit derived from these costs**. If costs include access to market quotas, then quota prices should be included in returns. If costs include those associated with government program participation, then government payments and other benefits should be included in returns. If access to water is included as a cost, the yield and/or quality arising from the use of that water should be reflected in the returns. Some general recommendations for estimating costs of rights to produce are provided here, followed by examples of some of the common rights to produce.

Costs to Acquire

Agricultural producers have two ways to acquire rights to produce as defined above. They can purchase them or rent (lease) them. How, if at all, they are explicitly included in CAR estimates depends on this method of acquisition. Where the rights to produce are inseparable from the costs of other resources (e.g., water with land, crop acreage base with land), no attempt to separate them should be made. These rights are usually capitalized into the cost of the other resources. Where the rights are separable from other resources or where they are easily transferable, the costs should either be capitalized separately or charged at a prevailing rental rate.

If it becomes absolutely necessary to identify production rights which are capitalized into other resources, two methods might be used. One method is to estimate the costs associated with gaining those rights. For example, what income was foregone (such as government payments or cash receipts) to increase crop acreage to establish a higher crop acreage base? What costs were realized in establishing conservation measures on a farm? Another method is the approach used in appraisal. That is, identify two resources (e.g., parcels of land) which are alike in all respects except that one includes a production right in its value, while the other does not. According to the market, then, the difference between the prices of the two resources is attributable to the production right.

Costs to Exercise

Owning (or renting) a right to produce does not always mean that the benefits of that right will automatically be realized. In the case of government commodity programs, ownership of a crop acreage base does no good unless the farmer complies with acreage reduction requirements. Having established an approved conservation compliance plan is not sufficient to derive program benefits if certain maintenance is required to stay in compliance. Having acquired grazing or hunting rights, agricultural producers are often required to perform certain measures or to comply with other restrictions to retain those rights. Maintaining a crop acreage base sometimes means devoting some acreage to a conserving use. In any event, any costs associated with retaining a right to produce or that arise as a condition of benefits of that right should be included as costs of production.

Examples of Determining and Allocating Rights to Produce

Following are some examples of cases where it is important to estimate the rights to produce. A detailed explanation of grazing fees is presented. More general explanations of the other cases are also given. However, the principles discussed within the grazing fees section apply equally to the other examples, as well.

Federal Grazing Fees

Fees for grazing federal lands came into existence in 1906 on Forest Service land and in 1936 for lands currently administered by the Bureau of Land Management (Torell, Bartlett, and Obermiller). The fees can be considered a lease rate on the forage or a tax on pre-existing grazing rights, depending upon one's point of view (Hage). The fees are charged on an Animal Unit Month (AUM) basis. An AUM is described as the amount of forage required to feed a 1,000-pound mature cow and her calf (or equivalent) for one month.

Grazing permits were originally allocated to western ranchers who could meet the "use-priority" and "commensurability" requirements. Use-priority meant that preference was given to those ranchers who were using the federal lands prior to the allocation of grazing permits and commensurability meant that the permit holder was a bona fide rancher who administered sufficient base property (land and/or water) to support the livestock when they were not utilizing the federal rangelands (Gardner). To encourage use and private investment on the rangelands, the original permits were given to ranchers gratis and the grazing fees were set at low levels (Torell and Doll). The difference between the cost of utilizing federal rangelands and the value of the forage was capitalized quickly into the value of the base ranch (Roberts). It has also been suggested by public land ranchers that part or all of the permit's value is not a capitalized rent, but an operating license, because the carrying capacity from the permit allows the deeded ranch property to become an economically viable operation (Torell, Bartlett, and Obermiller). Although this value was a windfall gain to the original owners of the grazing permits, an estimated 85% to 90% of the grazing permits have changed ownership (Nielsen and Workman), with the new owners disbursing some proportion of this capitalized value for the right to utilize federal rangelands.

Federal agencies administrating the grazing permits generally do not allow the owners of the permits to sublease them. In order for the grazing rights to be transferred to another rancher, the base property and/or livestock associated with the permit also must be transferred. Therefore, no market exists for the direct transfer of grazing permits between parties.

Federal rangeland leases also differ from most private pasture leases in that the users of the federal rangeland provide most, if not all, of the basic inputs associated with using the grazing permit. Costs such as rangeland improvements, fencing, grazing association fees, transporting or trailing cattle to the permit area, and supplemental feeding regimes can differ substantially from costs that would be incurred if the livestock were kept on deeded land or private pasture was leased. These costs can be readily identified and associated with the costs of utilizing federal rangelands.

The variable costs associated with utilizing federal grazing permits (e.g., federal grazing fee, grazing association fees, and transportation costs) can be included with variable costs. Either the capitalized value of the permit can be included in the value of the base property (Alternative 1) or the capitalized value of the range permit can be separated from the value of the base ranch and reported separately (Alternative 2).

> *Alternative 1*. The simplest and most commonly used method of accounting for the value of the federal grazing permit is to include it in the value of the base property. This is usually included in the rental value of the land. By so doing, the value of the grazing permit is accounted for in the CAR estimate, but is not specifically identified. This alternative alleviates the researcher having to undertake additional studies to determine the separate components included in the base ranch value.
>
> *Alternative 2*. The second alternative consists of separating the capitalized value of the federal grazing permit from the base property and reporting the two separately. The appropriate unit of measurement for reporting would be an Animal Unit Year (AUY), an AUM, or on a per cow basis (Torell and Doll).
>
> This alternative has the advantage of allowing users of the CAR estimate to see explicitly all costs associated with utilizing a federal grazing permit. To do so would necessitate a continual analysis of ranch sales with and without federal grazing rights to determine the current value of the grazing permit. This value would be dependent upon several factors, including the size of base ranch, the percentage of the forage base provided by the grazing permit, and the distance of the base ranch from the permit, and the productivity of the federal allotment.

Other complicating factors associated with valuing the grazing permit include the refusal of public land agencies to recognize the rancher's investment in the grazing permit as a true cost. Banking institutions are also becoming more hesitant to accept federal land grazing permits and leases as collateral for individual loans since a long-standing Forest Service and Farm Credit System Memorandum of Understanding was canceled in 1990 (Budd).

Although it is well established that federal grazing permits add to the value of ranches that have access to these permits (Collins; Fowler and Gray; Martin and Jefferies; Torell and Fowler; Torell and Doll), a market does not exist where grazing permits may be traded among parties unless the base property and/or cattle are also transferred. This makes the job of accurately separating the capitalized value of the grazing permit from the value of the base ranch infeasible on a large-scale basis. It is therefore recommended that these two values not be separated, but that a footnote acknowledge that the capitalized value of the grazing permit is included in the value of the land.

Market Quotas

If these quotas are transferable from producer to producer, either directly or through an intervening agency, the purchase cost of the quota should be capitalized or depreciated, depending on its expected lifetime. If the quota is attached to a production unit such as land, no cost of acquisition is separately identifiable and is included in the value of that production unit.

Government Programs

The rights to government farm programs are generally the establishment of a crop acreage base, the acquisition of quotas, or the compliance with certain regulations such as conservation compliance. Establishment of crop acreage bases occur over time through a history of crop production. Although there may be costs associated with establishing that base, those costs are normally capitalized into the value of the land and cannot be identified separately. Likewise, quotas for many government programs are established through production history and may fluctuate over time as the USDA attempts to control production. Again, the costs of these quotas, unless they are readily transferable, cannot be identified explicitly and are usually included in the price of other resources.

Costs of complying with certain regulations to retain eligibility for farm program benefits may include both investment and maintenance costs. The investment costs are likely to be capitalized into the value of land, while the maintenance costs are reflected as additional out-of-pocket costs of production.

Exercising the rights (farm program payments) gained through the establishment of a crop acreage base usually requires devoting some acreage to a conserving use. If the unit production being considered is an acre of crop acreage base, all the costs of exercising that right are included as part of the acre. When this occurs, however, production levels and costs reflect only that portion of an acre to which they apply. If the cost of production being considered is an acre of planted crop, then the commensurate net costs of maintaining the conserving use must be added. As discussed in Chapter 3, ***the Task Force recommends that CAR estimates for crops be done on a planted acre basis.*** Keeping revenue and cost calculations on a planted acre basis incorporates acreage not in production but needed for that particular production system.

Water Rights

Water rights in the United States have fallen into several categories depending on whether they pertain to surface or ground water (Goldfarb). For the most part, these rights accrue to the land and are capitalized into the land value. In some instances, particularly where appropriative rights laws are in place, water rights have been severed from the land, and are available through a separate water rights market. However, these water rights are currently evolving in many states, as the public becomes more involved in defining them. Hence, the general rule discussed earlier should be kept in mind when estimating costs of production: if the water rights accrue to the land, the costs are likely capitalized into the land value; if the rights are readily transferable, or if there is a ready market for water, then the costs of water rights are taken from that market and should be capitalized separately.

CONCLUSIONS

Rights to produce generally provide agricultural producers with access to markets, market enhancements, or resources essential in producing certain commodities. These rights must be both acquired and maintained if the producer wishes to derive any benefits associated with them. Costs of acquisition can either be capitalized costs of purchase or rental of them, while costs of maintaining the rights involve other steps taken to realize the full benefit of those rights or which assure the continued access to those rights. In any event, the benefits of these rights to produce should be accrued to any costs of acquiring and exercising them when developing CAR estimates.

Although it is recognized that many of the items discussed above "should" be included in determining the full economic costs of rights to produce, estimating these is really only feasible at the firm level, if at all. Collecting such information on an aggregate basis is neither feasible nor necessary. Instead, if the approach is taken that commodities are being produced by "going" concerns, many of the costs of acquiring rights to produce are capitalized into the value of other factors of production, particularly land. Therefore, only those rights to produce that are easily transferable should be included explicitly as costs within CAR estimates. In addition, costs incurred in exercising those rights, such as costs of participating in farm programs, should also be included only if farmers actually realize those costs. For example, exercising the right to participate in government farm programs includes protecting or maintaining a crop acreage base. This leads producers to plant the relevant program crop, even if an alternative crop might generate higher short term returns; i.e., an additional opportunity cost of participating in the program. These opportunity costs are difficult, if not impossible, to determine on the aggregate, and should be ignored.

CHAPTER 10

ALLOCATING PREPRODUCTIVE COSTS FOR MULTIYEAR ENTERPRISES

INTRODUCTION

Many enterprises require the development of assets that generate production for more than just one year. Perennial crop, tree fruit, nut, vineyard, breeding livestock, and dairy enterprises all produce revenue for multiple years, and each of these enterprise types also involves a period of time during which costs are incurred prior to productive periods. These costs must be accounted for in estimating production costs and returns (CARs) of multiyear enterprises.

This chapter defines terms associated with multiyear enterprises. Major issues associated with crop and livestock enterprises are explored as they pertain to preproductive cost determination and allocation. Alternative allocation methods are discussed emphasizing consistency with economic theory, limitations of the approaches, and proper interpretation of CAR estimates using each approach. The chapter concludes with general recommendations regarding the treatment of preproductive costs, including reporting issues such as format and classification of costs, as well as a discussion of the comparison of CAR estimates for enterprises with different lives. Long-lived assets such as breeding stock, trees, vines, and specialized facilities may have special tax treatment that could affect investment decisions. This discussion avoids these issues because they must be handled on a case-by-case basis.

DEFINITIONS

A **multiyear enterprise** is an enterprise with more than one annual production period. The **preproductive** period for a multiyear crop enterprise begins with the first expense associated with establishing the crop enterprise and ends in the crop year just before the crop yields a substantial percent of its expected mature yield (usually 70-80%). This definition is slightly broader than the definition used by the Internal Revenue Service (IRS), which specifies that "the pre-productive period ends when the plant becomes productive in marketable quantities..." (IRS: 34). For purposes of estimating economic CARs, it is more reasonable to end the preproductive period in the year just prior to the crop attaining a substantial portion of its long-run mature yield. The preproductive period may be equal to or greater than 12 months. For livestock, the preproductive period begins with the birth or purchase of animals to be used for breeding or milking, and ends at the beginning of the production year in which they begin production. For multiyear enterprises, a year is defined as a 12-month period that corresponds with either a calendar year or a production year. A **single-year enterprise** with a **multiyear preproductive period** is an enterprise that has harvestable yield in only one year but requires several years to establish and produce.

Consider a few examples to make the ideas clear. Alfalfa normally has a productive life of 3-4 years after the initial year of planting. Although there is usually some marketable alfalfa in this first year, it is standard to consider this year as one of preproduction with net production costs adjusted for the value of any crop produced, whether it be alfalfa hay or a companion crop such as oats. Dwarf apple trees normally begin yielding some marketable fruit in the fifth year following planting and reach production near mature yield in the seventh year. The trees usually cease having economic yield by the fifteenth year. In developing an annual budget for apples, one could use average yields over years 5-14 and assume that all costs in years 1-4 are preproductive; or, one could use average yields over years 7-14 and assume all net costs (allowing for the apple sales in years 5 and 6) are preproductive costs. Alternatively, one could use individual year-by-year yields for the productive period and create an annuity that has the same present value as the discounted costs over the productive years (5-14 or 7-14). If a dairy cow is purchased at the beginning of her productive life (ready-to-milk), she can be treated as a durable good and handled in a manner similar to equipment, as outlined in Chapter 6, where the difference between purchase price and discounted projected salvage value is amortized over her productive life as an annuity. If she is raised on the farm, it is still probably appropriate to use the going market price for a similar heifer as the initial cost and proceed as if she were purchased.

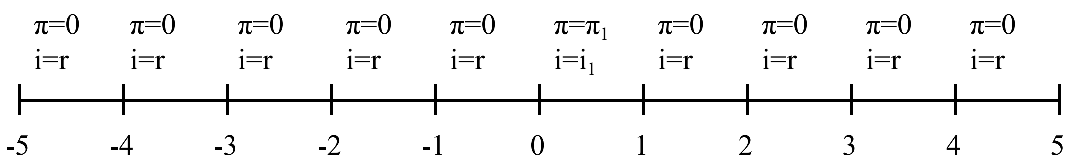
Enterprise costs that occur during the preproductive period are defined as **preproductive costs**. Preproductive costs include both operating costs and allocated overhead. These costs are estimated in exactly the same manner as enterprise costs for enterprises that are not multiyear. In order for an enterprise to be profitable, these preproductive costs, plus interest on the financial capital tied up in their production, must be recovered during the productive years of a multiyear enterprise. Therefore, the preproductive costs of an enterprise, plus interest, must be allocated as a cost of doing business over the productive years of the enterprise.

Two types of capital (durable) assets are defined with regard to multiyear enterprises. **Enterprise specific capital** is capital that is used only for the given enterprise and whose useful life is tied directly to the life of the enterprise. Enterprise specific capital is purchased during the preproductive period of a multiyear enterprise, and is disposed of or used up at the end of the enterprise's useful life. Acquisition costs of enterprise specific capital should be included as preproductive costs in the years they are acquired and allocated in conjunction with all other preproductive costs to enterprise production cost estimates. Examples of enterprise specific capital include trellis systems or irrigation systems that are constructed during the establishment period and removed when the enterprise is discontinued and trees or rootstock that are planted during the establishment period and removed when the enterprise is discontinued.

Other capital is used (or may be used) for more than a single enterprise and its useful life is not tied directly to the life of single enterprises. This distinction in capital is important in estimating costs for allocated overhead. The overhead costs of whole-farm durable assets are calculated and allocated according to procedures identified in Chapter 6 for both preproduction and production years. Examples of such durable assets include tractors, buildings, and irrigation pumps. Because these capital items are used for multiple enterprises, their annual costs must be allocated based on their proportion of use in each enterprise, as discussed in Chapter 9.

INFLATION ISSUES

Because preproductive costs occur over a period of years, inflation and the distinction between nominal and real interest rates must be considered. As suggested in Chapters 2 and 6, the convention will be to value all CAR streams in nominal values at the end of the current period and view the end of the current period as a base in computing real values for other periods. The convention is also that all CAR flows outside the current period are denominated in real terms relative to the end of the current period and that no inflation or deflation occurs except in the current period. This convention is followed because projected CAR estimates usually use current year nominal data to estimate costs for all previous and future years. In a time line context this can be represented as follows:



where π_j is the inflation rate in period j, r is the real interest rate (assumed constant), and i_j is the nominal interest rate in period j. We assume that inflation is constant and equal to zero in all but period 1. Thus we can compute the nominal interest rate in the first period as $i_1 = (1+\pi_1)(1+r)$. The current period ends at date 1 while the third preproductive period begins at date -3. If data on a period other than the current one are in nominal terms for that period, they should be adjusted to real terms for analysis unless there is an explicit desire to use nominal interest rates throughout. Historical CAR data will need to be converted to a real basis for analysis or else nominal interest rates must be used for discounting.

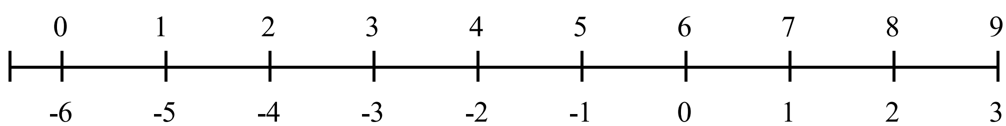
In a projected budget for the current year, the suggested approach is to compute all preproductive costs using current year projected nominal prices. These costs (and any returns) can then be adjusted to the end of the current period using the current nominal interest rate. These preproductive costs are then adjusted back in time to the end of each preproductive period using the current nominal interest rate for the current year and the real interest rate for years prior to the current one. This is similar to the approach suggested in Chapters 2 and 6 with regard to capital expense items that are purchased at the current time and used over several periods in the future. This is appropriate because projected data on costs are usually denoted in current values and that is how they are routinely collected. Returns that occur at the end of the current year should be expressed in nominal terms as of the end of the year because this is the base for CAR estimation. If data on CARs are for the beginning of the current period rather than the month of expenditure or receipt, they should be adjusted to the appropriate point in the period using the current inflation rate.

If data available on preproductive costs are nominal (relative to the current period) for the year the expense occurred, then they must be adjusted relative to the current time period using either the inflation rate and then the real interest rate or the actual nominal interest rate for the years in question in order to make the preproductive costs compatible with current end-of-year values. Given the need in such a nominal approach to consider multiple nominal interest rates, it is not recommended for projected budgets. When preparing historical estimates, the nominal approach may be used if year-specific data on preproductive costs are available and the desire is to compute an exact historical cost for a specific set of assets; otherwise, the real approach suggested for projected estimates may be used.

The Task Force recommends that preproductive costs be computed for each preproductive year using current nominal CAR data. These costs should be adjusted to the end of the respective year using the current nominal interest rate. The Task Force suggests that these costs be adjusted to reflect expenditure at the end of their period of occurrence relative to the current one by using the current nominal interest rate for the current year and the real interest rate for years prior to the current year.

For historical budgets, the Task Force suggests the use of historical costs and nominal interest rates only in cases where there is excellent data and the desire is to estimate costs for a specific asset structure.

To make these points clear, consider a simple example where a farmer plants Christmas trees in year 1 and harvests them all in year 7 (assuming no residual crop in the eighth year). The CARs for each year are adjusted to be in nominal terms at the end of the seventh year. These values are also real values for this time point because the end of this year is the point at which CARs are estimated. The constant real interest rate is assumed to be 2% with a nominal rate of 7.1%. This implies a 5% rate of inflation [(.02)+(.05)+(.02)(.05) = .071] during the current year. To make the time points explicit, consider a time line like that presented in Chapter 2 where the numbers above the line consider the current period to end at 7 while the numbers below the line consider it to end at 1.



Points 0 and 6 are then the same point (the beginning of the current period), but numbered in alternative fashions. Given the normal convention that the end of the current period is point 1 and using negative indexing to reflect preproductive costs, the value of all CAR items at the beginning and end of the first period are presented in Table 10.1. It is assumed that all expenses occur in the middle of the year and are then adjusted to the end of the respective year using the nominal interest rate for the current year because the data are assumed to be in nominal terms for the current year. This means that they will accrue operating interest at the current nominal interest rate. Because these costs occur prior to the current period (i.e., they are preproductive costs) they will also accrue interest between their year of occurrence and the current period. To reflect this opportunity cost of financial capital, the preproductive costs must be adjusted accordingly. We assume that inflation is zero in all but the current period, which means that they are adjusted using the real interest rate for all periods except the current one, and using the nominal interest rate for the current period. Returns are assumed to occur on December 31. Notice that the nominal interest rate used within years for adjusting the expenditures to year end is 7.1%. The nominal interest rate used between years (except between 0 and 1) to adjust values to previous or future periods is equal to the real rate of 2%. Consider first the costs of $1,500 in the establishment year. It is assumed that this is the projected nominal cost for the current year and that this cost will occur on midnight June 30. This is adjusted to the end of the year using the nominal interest rate of 7.1% as suggested by equation 2.15. This is repeated here for convenience.

$$ic = R_t^{mn}(1+i)^{\frac{mn}{12}} - R_t^{mn} \tag{2.15}$$

where R_t^{mn} is a nominal expenditure occurring mn months from the end of the year t. If the interest charge is given by ic, then the value of the expenditure R_t^{mn} at the end of the year is

$$R_t = R_t^{mn}(1+i)^{\frac{mn}{12}} \tag{10.1}$$

where the 0 superscript on R_t is suppressed. This gives a value of $1,552.3369 [(1,500)(1.071)$^{.5}$] because the payment occurs at midyear. Similarly, the cost in the second year of $190 is adjusted to the end of that year to obtain $196.6293 [(190)(1.071)$^{.5}$]. Because the costs in the establishment year did not occur during the harvest year but during the fifth year prior to it, they should be adjusted to reflect opportunity interest. This is done using the real interest rates for each year prior to the harvest (current) year and the nominal interest rate reflecting inflation level in the current year. Thus the cost of $1,552.3369 is adjusted to yield $1,835.593 as follows:

$$\begin{aligned} \textit{Value of establishment year expenditure at end of year } 1 &= (1,552.3369)(1.02)^5(1.071) \\ &= (1,552.3369)(1.10408)(1.071) \\ &= (1,713.904)(1.071) \\ &= 1,835.593. \end{aligned}$$

This can be done for each year as in Table 10.1. Notice that in year 0 there is no adjustment because these costs are already in year-end values. Total preproductive costs are then $2,931.512 in end-of-year 1 values. These can be adjusted to the beginning of the year using the nominal interest rate as follows:

$$\begin{aligned} \textit{Value of preproductive expenditures at beginning of year } 1 &= \frac{(2,931.512)}{(1.071)} \\ &= 2,737.172. \end{aligned}$$

Costs in the production year of $1,000 are adjusted to the end of the year using the nominal interest rate and are equivalent to $1,034.89. Total costs for the year are then $3,966.403 [(1,034.89) + (2,931.512)]. These are then subtracted from sales revenue of $4,000 to obtain net returns in end-of-year dollars of $33.597.

TABLE 10.1 Costs and Returns for Production of Christmas Trees

			Inflation rate for within-year adjustments	Nominal i for within-year adjustments	Inflation rate for between-year adjustments	Nominal i for between-year adjustments
Real interest rate	0.02	Year				
Inflation rate (current year)	0.05	-6	0.05	0.071	0	0.02
Nominal interest (current year)	0.071	-5	0.05	0.071	0	0.02
		-4	0.05	0.071	0	0.02
		-3	0.05	0.071	0	0.02
		-2	0.05	0.071	0	0.02
		-1	0.05	0.071	0	0.02
		0	0.05	0.071	0	0.02
		1	0.05	0.071	0.05	0.071

Year	Nominal cost at expenditure point in year i	Nominal income at end of year i	Nominal cost at end of year i	Cost adjusted to end of year 0	Income adjusted to end of year 0	Cost adjusted to end of year 1	Income adjusted to end of year 1	Net Income adjusted to end of year 0	Net Income adjusted to end of year 1
-5	1,500		1,552.336948	1,713.905	0.000	1,835.593	0.000	-1,713.905	-1,835.593
-4	190		196.6293467	212.838	0.000	227.949	0.000	-212.838	-227.949
-3	190		196.6293467	208.665	0.000	223.480	0.000	-208.665	-223.480
-2	190		196.6293467	204.573	0.000	219.098	0.000	-204.573	-219.098
-1	190		196.6293467	200.562	0.000	214.802	0.000	-200.562	-214.802
0	190		196.6293467	196.629	0.000	210.590	0.000	-196.629	-210.590
1	1,000	4,000	1,034.891299	966.285	3,734.827	1,034.891	4,000.000	2,768.542	2,965.109
Total cost, revenue, net return				3,703.458	3,734.827	3,966.403	4,000.000	**31.370**	**33.597**
Total preproduction cost, revenue, net return				**2,737.172**	0.000	**2,931.512**	0.000	-2,737.172	-2,931.512

ENTERPRISE ISSUES

Crops

Some crops may entail multiple preproductive years but only one production year. Examples include Christmas trees, such as the above example, and nursery products. For these crops, the problem to be addressed is not the allocation of preproductive costs over several production periods, but rather the correct procedure to use in discounting (or compounding) the annual preproduction and production costs. Assuming the goal is to estimate CARs at the end of the production year, the preproductive costs should be compounded to reflect the time value of money. Total compounded preproductive costs are then added to production year costs, and this total is subtracted from the gross returns estimates to get net returns in current dollars.

Another issue that arises for crops is determining the first operation for site preparation. Recall that the first expense associated with establishing a new crop determines the beginning of the preproductive period. The nature and cost of this first operation depends largely on the previous crop or use of the land. The condition of the land prior to the first site preparation operation should be specified to allow those using the CAR estimates to adjust costs accordingly. For example, when a new tree crop is planted to replace an old one, do we charge the cost of removing the old trees to the preproductive costs of the new orchard or do we charge the cost of removing the new orchard at the end of its life? A farmer in this situation pays for removal prior to planting the new enterprise, so we suggest that the costs of removal be included as establishment costs for the new enterprise. What if the new orchard is being planted where no orchard existed previously? The costs of removal are not paid by producers prior to planting in this case, so no removal costs are included in preproductive costs.

Some crops entail enterprise specific capital costs that do not match the life of the enterprise. An example is hop enterprises. Typically, more than one hop rootstock planting is used during the life of the hop enterprise. For cases such as this, the costs of purchasing and planting the rootstock are allocated over the shorter expected life of the rootstock instead of the expected life of the enterprise.

A final issue to consider is whether preproductive costs are ever involved in producing annual crops. Practices such as terracing, leveling, or tiling may be performed prior to production of annual crops. These practices result in benefits over a period of many production years, and should not be charged as annual expenses. Should they be treated as establishment costs? These practices are not really tied to the life of the enterprise, so they are not enterprise specific capital. Their costs are ultimately reflected in the land values to which they are attached. See Chapter 6 on machinery, buildings, and equipment, and Chapter 7 on land for a discussion of the treatment of these costs.

Livestock

The most significant preproductive cost for livestock enterprises is the cost of acquiring breeding or milking stock. Accurate estimation of this cost is difficult because many livestock operations raise many of their own replacement animals, often in the same or similar manner as their market animals. This makes the identification and estimation of costs specifically tied to raising replacement animals difficult and results in inaccurate cost estimates. Ways to account for establishment costs in livestock enterprises are (1) use the traditional method that allocates preproductive costs based on straight-line depreciation and opportunity interest; (2) capitalize the price of purchased replacement animals or actual costs of the production of raised replacement animals over the life of the breeding livestock; (3) use current costs of production for replacement animals in the production system treated as a whole in a steady-state type of analysis; (4) use market values for replacement animals based on replacement rates (cull rates) as an opportunity cost for a steady-state analysis similar to (3); and (5) use historic costs of raising replacement animals as their value based on replacement rates (cull rates) as an opportunity cost for a steady-state analysis similar to (3). These methods are each discussed in the section entitled Allocation Methods.

DETERMINING PREPRODUCTIVE COSTS (NET RETURNS)

Preproductive costs are estimated by calculating the negative of preproductive net returns in each preproductive year and then adjusting them to the end of the last preproductive year. Net preproductive costs for an enterprise are calculated as

$$PPC = \sum_{j=1}^{J} (1+r)^{J-j}(-R_j) \qquad \textbf{(10.2)}$$

where

PPC = total preproductive cost
j = index for j^{th} preproductive year
J = length of preproductive period in years
r = real interest rate and
R_j = real net return in year j.

PPC is calculated in the same units as the productive years of the enterprise (usually on a per acre or per head basis). R_j measures annual net returns for preproductive years of the enterprise, and is calculated as total returns minus total annual cost. Equation 10.2 assumes that the R_j values are adjusted to year-end values on the last day of year j by including nominal interest on operating capital to reflect the cost associated with payment of expenses earlier in the year. The real interest rate, r, is used to calculate the opportunity costs of these expenditures in adjusting them from each year in the preproductive period to the production periods. If the preproductive costs are expressed in nominal values for the preproductive years, they must instead be adjusted by a nominal interest rate. These can then be adjusted to the end of the first production period by multiplying them by (1+i) where i is the nominal interest rate thus including inflation for the first productive year. If the discounted sum of preproductive net returns is positive then it is included in the CAR as a revenue instead of an expense. An example might be where yields and prices for a year of alfalfa establishment are so large that they cover the total costs of establishment.

Nominal preproductive CAR estimates for alfalfa are shown in Table 10.2. The preproductive period is one year. The net return in the preproductive year is $-157.89, which is calculated by subtracting the preproductive cost of $322.059 from total preproductive returns of $164.17. With a real interest rate of 5%, an inflation rate of 2%, and a nominal rate of 7.1%, preproductive cost is $157.89 using equation 10.2. Because J=1, no compounding is required; the preproductive cost is already estimated as of the end of the preproductive year. These costs could be multiplied by (1+i) to put them at the end of the first productive year rather than the end of the preproductive year.

TABLE 10.2 Establishment Year CARs for Alfalfa Hay (i = 7.1%)

Cost or Revenue	**Description**	**Units**	**Quantity**	**Price/Unit**	**Months to end of period**	**Implicit interest factor**	**Value at end of period**
Alfalfa Hay	July Cutting	ton	1	$80.00	5	1.029	82.32
Alfalfa Hay	August Cutting	ton	1	$80.00	4	1.023	81.85
Total Revenue							**164.17**
Seed	Alfalfa	lb	20	2.95	8	1.047	61.76
Inoculant	Alfalfa type	pkg	0.5	2.4	8	1.047	1.26
Fertilizer	N	lb	15	0.25	9	1.053	3.95
	P205	lb	60	0.23	9	1.053	14.53
	K20	lb	190	0.15	9	1.053	30.00
	Boron	lb	2	2.38	9	1.053	5.01
	Lime	ton	3	16	9	1.053	50.53
Weed Control	Balan	qt	3	4.13	9	1.053	13.04
	Custom app	acre	1	4	9	1.053	4.21
	2,4-DB	gal	0.63	40.5	8	1.047	26.71
	Custom app	acre	1	4	8	1.047	4.19
Machinery Costs		acre	1	77.34	6	1.035	80.04
Labor		hour	4.37	6	4	1.023	26.83
Total Cost							**322.06**
Net Return							**-$157.89**

Almond preproductive costs are shown in Appendix 10A and summarized in Table 10.3. The example assumes a nominal interest rate of 9% and a real rate of 4% with an implied inflation rate of $\pi = \frac{i - r}{(1 + r)} = \frac{(0.09 - 0.04)}{1.04} = .048077$. It is assumed all expenses are adjusted to the end of each preproductive year using the nominal rate of interest. The total almond preproductive period is six years, and the net returns for each of these six years vary. The total estimated life of the trees is 25 years, including the preproductive period. The first almond crop is harvested in year 4, and full production is not reached until year 7. Using equation 10.2 with r = 4%, J = 6 years, and R_j as shown in Table 10.3, the total preproductive cost for almonds adjusted to the beginning of year 7 is estimated as $4,494.67. For example, the first year cost of $1,895 (in end-of-period 6 nominal terms) accrues interest for five years from the end of year 1 to the beginning of year 7. This gives an accrued cost of $2,305.557 [(1,895)$(1.04)^5$]. This could be adjusted to the end of year 7 by multiplying by the interest rate for the production year.

TABLE 10.3 Annual Preproductive Net Returns for Almonds

Year	Net Return ($/acre) at end of year i	Net Return adjusted to the end of year 6
1	-1,895	-2,305.557
2	-718	-839.958
3	-788	-886.393
4	-600	-648.960
5	-70	-72.80
6	+259	+259.00
Sum		-4,494.669

Source: Appendix 10A. Sample Costs to Establish and Produce Almonds in the Northern San Joaquin Valley.

ALLOCATION METHODS

Once preproductive costs are determined, they must be allocated over time to the production enterprise if the enterprise has more than one production period. There are a variety of ways to allocate these costs. Examples from alfalfa, almond, and dairy enterprises will be used to illustrate the methods suggested.

Traditional Budgeting Method

The first method to consider is the traditional one described in equations 6.5 and 6.6. The traditional method allocates ownership costs of durable assets to enterprise CAR estimates based on charges for opportunity interest and service reduction/depreciation (Garst). Although these methods are most commonly used for machinery, equipment, and buildings, the same principles apply to establishment costs for multiyear enterprises (Casler and White; Chapter 6 of this report). Including depreciation and interest charges is consistent with economic theory. Depreciation expenses represent the decline in value of an asset over its useful life due to age, use, and obsolescence (Castle, Becker, and Nelson). Interest charges represent the opportunity cost of capital invested in assets.

Annual establishment depreciation expense (D) is generally calculated using straight-line depreciation as

$$D = \frac{(PPC - SV)}{(N - J)} \tag{10.3}$$

where SV is the terminal or salvage value of the enterprise at the end of its life valued in the same dollars as total preproductive cost, J is the number of preproductive years, N is the total life of the enterprise, and N-J is the productive life of the enterprise. It is assumed that PPC is expressed as a beginning-of-period value. If SV is expressed in real dollars at the end of the useful life, it enters equation 10.3 unadjusted. If SV is expressed in nominal dollars, it should be deflated by $(1+\pi)^{N-J}$ where π is the assumed annual inflation rate over the remainder of its life. Annual depreciation expense for alfalfa establishment, assuming a salvage value of 0 and a remaining life of 4 years, is $39.472 [(157.889)/(4)]. Depreciation on the almond orchard, assuming a 0 salvage value and a 19-year remaining life, is calculated as $236.562 [(4,494.669)/(19)] annually.

Annual opportunity interest expense (OC) is typically calculated as

$$OC = \left(\frac{PPC + SV + D}{2}\right)(r) . \tag{10.4}$$

This estimates annual interest on preproductive cost based on its average value over the life of the enterprise (Boehlje and Eidman). Kay (1974) and Walrath have shown the traditional method of calculating depreciation and interest expenses with $OC_{trad} = \left(\frac{PPC + SV}{2}\right)(r)$ underestimates actual costs in the sense that it will not fully recover initial investment. The estimate of annual depreciation is added back in the numerator in equation 10.4 to better reflect the actual opportunity cost of holding the asset (Chapter 6; Walrath; Kay (1974); Watts and Helmers (1979)). Using a real interest rate of 5% for the alfalfa example, annual opportunity interest expense for alfalfa preproductive cost is calculated with equation 10.4 as [(157.889 + 0 + 39.472)(.05)]/2 = $4.934, whereas opportunity interest at a 4% annual rate on the almond preproductive cost is [(4,494.669 + 236.56)(.04)]/2 = $94.625.

Total annualized preproductive cost using the traditional budgeting approach (A_{TB}) is therefore

$$A_{TB} = D + OC \; . \qquad \textbf{(10.5)}$$

This annualized preproductive cost is included in annual production budgets for multiyear enterprises. Total annualized preproductive cost for alfalfa using equation 10.5 is (39.472 + 4.934) = $44.406. Annualized almond preproductive cost estimated using the traditional budgeting method is 236.56 + 94.6246 = $331.186.

Although the concepts of depreciation and interest are proper for handling preproductive costs, implementing these concepts often proves to be awkward and inaccurate. Preproductive costs per unit must be calculated for each year of the preproductive period. Calculation of depreciation expenses requires selection of a depreciation pattern, and the pattern selected often does not reflect actual changes in value. Although depreciation seems inappropriate for those time periods when assets appreciate in value, it is certainly reasonable to calculate depreciation for assets that provide services over a finite useful life (United States Department of the Treasury). Thus, depreciation patterns are usually selected to simply recover total asset basis, with little emphasis on their pattern over time.

Interest calculations are also perplexing for investments in multiyear enterprises. An interest rate must be chosen that reflects the cost of capital to the firm, and applied to appropriate valuations of total preproductive cost. Given the changes in value of multiyear enterprise investments, selecting the "correct" value to use in calculating an opportunity cost is difficult. As suggested in Chapters 2 and 6, a more accurate alternative is to use the cost recovery method to allocate precisely the preproductive costs.

Cost Recovery (Annuity) Method

Cost recovery is used to recover combined charges for depreciation and interest over an asset's life, and this approach works well for preproductive costs of multiyear enterprises. The cost recovery method accrues annual preproductive returns to a future value at the end of the preproductive period, then amortizes these costs over the productive life of the enterprise. The resulting annual amortization charge includes both interest and depreciation expenses. This approach applies equally well to crop and livestock multiyear enterprises. This is exactly the approach suggested in Chapter 2, equation 2.31 and in Chapter 6, equation 6.8.

The first step in allocating preproductive costs using the cost recovery method is to calculate total preproductive cost, again following equation 10.2. This represents the value of the costs at the beginning of the productive period. Next, annualized real preproductive cost (A_{CR}) is calculated as

$$A_{CR} = \frac{\left(V_0 - \frac{V_n}{(1+r)^{(N-J)}}\right)}{\left(\frac{1 - \frac{1}{(1+r)^{(N-J)}}}{r}\right)} = \frac{\left(PPC - \frac{SV}{(1+r)^{(N-J)}}\right)}{\left(\frac{1 - \frac{1}{(1+r)^{(N-J)}}}{r}\right)} \tag{10.6}$$

where J is the number of preproductive years, N is the total life of the enterprise, and SV is the salvage value of the enterprise in the same dollars as PPC. A_{CR} can also be computed using the standard payment function (such as PMT in EXCEL) on financial calculators or spreadsheets. In such cases the present value is $\left(PPC - \frac{SV}{(1+r)^{N-J}}\right)$. The end-of-the-year payment option should be used. This annualized real preproductive cost is then adjusted to the end of the first year by multiplying it by $(1+\pi)$ where π is the inflation rate and by $(1+\pi)^j$ for periods j > 1 if a nominal analysis for periods in the future is used. For further discussion, see equation 2.32 and the analysis following.

Annualized preproductive cost for the alfalfa example can be calculated using equation 10.6. The total preproductive cost was previously calculated as PPC = \$157.89. With r = 5%, SV = \$0, N = 5, and J = 1 we can compute A_{CR} as

$$A_{CR} = \frac{\left(157.89 - \frac{0}{(1.05)^{(5-1)}}\right)}{\left(\frac{1 - \frac{1}{(1.05)^{(5-1)}}}{.05}\right)} = 44.5268 \quad ,$$

which is slightly greater than the annualized preproductive cost of \$44.406 estimated using the traditional budgeting approach. This beginning-of-year value could be multiplied by the inflation rate of 2% to make it a nominal value at the end of period 1 ((44.527)(1.02) = 45.417). This value would remain the same for future periods if the inflation rate for these future periods were assumed to be zero. Alternatively, it could be increased each year to account for projected inflation.

The annualized cost (A_{CR}) for the almond example is $342.218, assuming PPC = $4,494.67, r = 4%, SV = $0, N = 25, and J =6. If there is inflation in the current year then this real annuity must be adjusted to the end of the year to be comparable with other CARs. This inflation-adjusted annuity is $358.6706 [(342.2179)(1.048077)]. A year-by-year analysis for the almond example is contained in Table 10.5 where it is assumed that inflation of 4.8077% occurs in year 7 only. The nominal interest rate is assumed to be 9% during year 7 and equal to the real rate of 4% during all other years. Column 1 lists the expenditures each year in nominal values. Because there is assumed to be no inflation during the preproductive period, these are also real values as of the end of year 6. Rather than charging the enterprise the preproductive costs in column 1 over each preproductive years of the enterprise, the annualized preproductive costs equaling $358.6706 are charged each year during the production period. The net present value of the annual costs for the first six years shown in column 1 equal the amortized preproductive costs for years 7 through 25 in column 2.

Watts and Helmers (1981) illustrate that the cost recovery method is preferred over the traditional method under conditions of inflation. Walker and Kletke point out that the cost recovery method provides more accurate estimates when flows occur over time (a characteristic of establishment costs for perennial crops). A formal mathematical approach accounting for variable productivity over time has been developed by Burt (1992) and is discussed in Appendix 10B.

The cost recovery method requires almost the same data as the traditional budgeting method. No assumption of depreciation patterns is needed because equation 10.6 does not depend on a functional form, but rather is based on the value of preproductive cost and the salvage value of the enterprise.

Current Cost Method

Another method available for allocating preproductive costs includes the current costs of establishing some portion of a multiyear enterprise in annual production CAR estimates. For example, a dairy budget might include the operating and capital costs for a cow and her share on a percentage basis of a replacement animal. This approach is commonly used in constructing livestock enterprise CAR estimates (Smith, Knoblauch, and Putnam; McSweeny and Jenkins; Foley and Justus; USDA, 1990). USDA (1991) also has used this approach in estimating tree fruit enterprise CARs.

The primary advantage of the current cost method over the previous two methods is simplicity. Growers report their total costs for a multiyear enterprise, including costs for portions of the enterprise that are not yet productive. They also specify the relative rate at which replacement of the enterprise is occurring (e.g., the number of replacement animals added to a breeding herd, or the number of acres of new orchard being developed). Average costs, returns, and replacement rates can then be calculated. This method represents a type of "long-run equilibrium" where it is assumed that the enterprise is in a "steady state" and establishment costs are constant year after year. Thus the inventories of cows, heifers, sows, immature trees, mature trees, rootstock, vines, and the like are assumed to be the same at the beginning and end of each year. Sales of cull animals will balance with new animals added, trees removed will balance with trees beginning to bear, and so forth. Because assets are not normally bought and sold each period, Chapter 2 suggested ways to compute an annuity that represents the costs of holding and using the asset. This approach is suggested in equation 10.6.

If the number and age distribution of assets in the operation do not change, a more direct approach is to use the current cost method (equation 10.7 directly).

The easiest way to visualize the current cost method is to consider an example such as a dairy cow. Suppose an asset (the dairy cow) is purchased at the beginning of the year with beginning-of-year nominal value V_0^j where j denotes that this is the jth asset. Assume that operating costs associated with the asset during the year are given by C_1^j and are already adjusted to the end of the year using the nominal interest rate assumed. At the end of the period, assume that the asset is sold with nominal (and real) value V_1^j. The net cost of holding and using the asset during the period (NC_1^j) is then given by

$$NC_1^j = iV_0^j + (V_0^j - V_1^j) + C_1^j. \qquad \textbf{(10.7)}$$

where V_k^j is the value of the asset at the end of period k and C_1^j is the operating cost of the asset during period 1. This can also be written using the real interest rate (r) as follows

$$\begin{aligned} NC_1^j &= rV_0^j(1+\pi) + [(1+\pi)V_0^j - V_1^j] + C_1^j \\ &= rV_0^j + \pi r V_0^j + V_0^j + \pi V_0^j - V_1^j + C_1^j \\ &= (\pi + r + \pi r)V_0^j + V_0^j - V_1^j + C_1^j \\ &= iV_0^j + [V_0^j - V_1^j] + C_1^j. \end{aligned} \qquad \textbf{(10.7r)}$$

The first line adjusts the nominal value V_0^j to a real end-of-year value by multiplying it by the inflation rate and then applies a real interest rate to evaluate opportunity cost. Real economic depreciation is given by $(1+\pi)V_0^j - V_1^j$ because V_0^j is a nominal beginning-of-period value. The lines following show the equivalence in the expressions 10.7 and 10.7r using the identity i = π + r + πr. The first term in each expression is opportunity interest, the bracketed term is economic depreciation, and the last term is the operating and maintenance cost associated with the asset. Any purchases of assets (such as breeding animals or trees) are counted as an expense this period in the form of V_0^j whereas any assets sold (such as cull cows or ewes) are counted as a revenue in the form of $-V_1^j$. Only a portion of the assets associated with most enterprises are usually bought and sold in a given period. For assets not bought or sold during the period it is standard in CAR estimation to assume that $(1+\pi)V_0^j = V_1^j$ so that the net cost is just $NC_1^j = r(1+\pi)V_0^j + C_1^j = (i - \pi)V_0^j + C_1^j$. For an entire enterprise the net cost of holding and using the assets for the first period is then

$$\begin{aligned}\sum_{j=1}^{m} NC_1^j &= \sum_{j\neq k}\left(r(1+\pi)V_0^j + C_1^j\right) + \sum_{j=k}\left(r(1+\pi)V_0^j + ((1+\pi)V_0^j - V_1^j) + C_1^j\right)\\ &= \sum_{j=1}^{m}\left(r(1+\pi)V_0^j + C_1^j\right) + \sum_{j=k}\left((1+\pi)V_0^j - V_1^j\right)\\ &= \sum_{j=1}^{m} r(1+\pi)V_0^j + \sum_{j=1}^{m} C_1^j + \sum_{j=k}(1+\pi)V_0^j - \sum_{j=k} V_1^j\end{aligned} \qquad \textbf{(10.8)}$$

where k indexes those assets that are bought or sold during this period and the index m includes all assets associated with the enterprise. For all assets not bought or sold, we implicitly assume that $(1+\pi)v_0^j = v_1^j$.

This implies that we use as the net cost of these assets their opportunity interest, operating costs, the purchase of any replacement items, and any revenues from their sale.

In many situations an enterprise may produce rather than purchase assets. An example is beef heifers or gilts. In this case, the term $\sum_{j=k}(1+\pi)v_0^j$ would be excluded from equation 10.8. The costs would be computed using 10.9

$$\sum_{j=1}^{m} NC_1^j(\text{current cost}) \equiv \sum_{j=1}^{m} r(1+\pi)V_0^j + \sum_{j=1}^{m} C_1^j + \sum_{j=k} -V_1^j . \qquad \textbf{(10.9)}$$

Note, however, that current costs associated with producing these assets for future use, $\sum_{j=1}^{m} c_1^j$, are still included. Thus for example, the cost of feeding a heifer this year to be of breeding age would be included. The current cost method uses this approach to account for costs of producing and operating assets and also includes revenues from the sale of the assets.

The current cost method can be first illustrated using the alfalfa example where there are no assets purchased but there are operating costs associated with a portion of the operation from which there is minimal saleable production. If a given percentage of total acreage is established each year, then the same percentage of establishment cost should be included in the production CAR estimate. One year of establishment and four years of production imply that 25% of every producing acre (20% of total acres) is being established each year. Therefore, 25% of the total alfalfa preproductive cost of $157.89 (Table 10.2) should be included to represent preproductive costs in the production CAR estimate. This represents an annual preproductive cost of $39.472. If the annual returns to an acre of alfalfa yielding 4 tons per year are $379.433 and annual costs, excluding establishment, are $282.539, then returns over annual costs are $96.894. Returns over all costs would then be $57.422 (96.894-39.472). Table 10.4 contains a CAR estimate for an alfalfa system. The example assumes a real interest rate of 5%, an inflation rate of 2%, and a nominal interest rate of 7.1%. The system is not based on a one-acre unit but rather is based on five acres of land, four in production and one in establishment. If we then convert these five acres to a one-acre unit, we have a "representative" acre with 80% in production and 20% in preproduction. Because land charges were not included in any of the costs, an acre of productive land in this system requires 1.25 acres of land. If land rent were $40.00 per acre and paid at the end of the year, the owner of this operation would have a net return of $7.422 [57.422-(40)(1.25)] per acre. Total returns for the five-acre system are $229.686 (1,681.902 - 1,452.216). With a land charge of $40.00 per acre this gives a net return of $29.686 (229.686-200). On a total acre basis this is $5.937 (29.686/5) per acre. On a production acre basis this is $7.422 per acre ((5.937)(1.25) or 29.686/4). If land rent were paid over the year, operating interest would need to be charged on this expenditure.

There are several limitations of the current cost method that must be recognized. First, the time value of money is not explicitly incorporated into the analysis. Preproductive costs of future productive resources are charged against current productive resources because the purchases and sales included are not for the exact same assets. This is only appropriate when estimating costs for an enterprise that is in long-run equilibrium and where the initial start-up costs or conditions are no longer important.

A second problem relates to changes in technology and production practices. Current preproductive practices may differ from the practices used to establish the current productive portion of the enterprise. For example, an orchard may switch to higher densities of tree plantings, resulting in significantly higher preproductive costs relative to the existing productive orchard. Mixing the high-density preproductive costs with low-density production CARs results in incorrect estimates of profitability. In fact, the high-density planting should be treated as a new enterprise, rather than a replacement of the low-density planting.

Changes in establishment rates for new enterprises among growers can lead to problems in estimating CARs. If the rate of new establishment within an enterprise is constant among growers and represents the long-term replacement rate needed to maintain a productive enterprise, then CAR estimates based on the current cost method reflect long-run estimates of economic profitability (in the absence of technological or cultural changes discussed above). However, in some years weather or market factors may cause short-term shifts in establishment rates, leading to abnormally high or low preproductive costs in current or succeeding years.

As an example, consider an unusual freeze occurring in the citrus industry in California. A severe, prolonged freeze would potentially damage or destroy many trees, but the real extent of this damage may not be realized until up to one year later, when trees actually die or demonstrate reduced production levels. Establishment rates in citrus groves would increase over several years due to tree losses, changing the percentages of bearing trees for several years. Resulting CARs attributed to productive trees would increase substantially in the short run, due to higher establishment rates. This leads to CAR estimates that are not reflective of long-run productive citrus enterprises, if the purpose of the estimates is to prepare management budgets for recommended production practices. However, if the purpose is to estimate actual historical costs, no problem arises.

TABLE 10.4 Total Cost for 4 Acres of Alfalfa Hay and 1 Acre of Alfalfa Establishment (i = 7.1%)

Cost or Revenue	Description	Units	Quantity	Price/ Unit	Months to end of period	Implicit interest factor	Value at end of period
Alfalfa Hay	May Cutting	ton	3.6	$80.00	7	1.041	299.757
Alfalfa Hay	June Cutting	ton	5.6	$80.00	6	1.035	463.631
Alfalfa Hay (estab)	July Cutting	ton	1	$80.00	5	1.029	82.319
Alfalfa Hay	July Cutting	ton	6	$80.00	5	1.029	493.916
Alfalfa Hay (estab)	Aug Cutting	ton	1	$80.00	4	1.023	81.850
Alfalfa Hay	Sep Cutting	ton	3.2	$80.00	3	1.017	260.428
Production Year Revenue							1,517.733
Total Revenue							1,681.902
Establishment Costs							
Seed	Alfalfa	lb	20	2.95	8	1.047	61.761
Inoculant	Alfalfa type	pkg	0.5	2.4	8	1.047	1.256
Fertilizer	N	lb	15	0.25	9	1.053	3.948
	P205	lb	60	0.23	9	1.053	14.529
	K20	lb	190	0.15	9	1.053	30.005
	Boron	lb	2	2.38	9	1.053	5.011
	Lime	ton	3	16	9	1.053	50.534
Weed Control	Balan	qt	3	4.13	9	1.053	13.044
	Custom app	acre	1	4	9	1.053	4.211
	2,4-DB	gal	0.63	40.5	8	1.047	26.709
	Custom app	acre	1	4	8	1.047	4.187
Machinery Costs		acre	1	77.34	6	1.035	80.038
Labor		hour	4.37	6	4	1.023	26.826
Land	Rental	acre	0	40	0	1.000	0.000
Total Establishment Costs							322.059
Production Year Costs							
Fertilizer	P205	lb	240	0.23	9	1.053	58.114
	K20	lb	760	0.15	9	1.053	120.018
	Boron	lb	8	2.38	9	1.053	20.045
Insect Control	Furadan 4F	qt	4	17.04	7	1.041	70.943
Weed Control							
Post-Emerge (2 of 4 acres)	Poast plus	gal	0.52	22	6	1.035	11.839
	Crop oil	gal	0.52	8.08	6	1.035	4.348
	Custom app	acre	2	4	6	1.035	8.279
Post-Emerge (2 of 4 acres)	2,4-DB	gal	1.28	40.5	8	1.047	54.266
	Custom app	acre	2	4	8	1.047	8.374
Post-Emerge	Gramoxone extra	pt	4	4.04	10	1.059	17.111
	Surfactant	qt	1	2.71	10	1.059	2.869
	Custom app	acre	4	4	10	1.059	16.941
Hay Preservative	Fresh cut(80% of crop)	lb	96	1.35		1.000	129.600
Twine		bale	800	0.05		1.000	40.000
Labor		hour	27.16	6	4	1.023	166.729
Machinery Fuel		acre	4	11.95		1.000	47.800
Machinery Repairs		acre	4	27.31		1.000	109.240
Machinery & equipment	Depreciation & Interest	acre	4	60.91		1.000	243.640
Land	Rental	acre	0	40	0	1.000	0.000
Total Production Year Cost							1,130.156
Total Cost							1,452.216
Production Year Return							1,517.733
Production Year (Return - Cost)							387.576
Total Return							1,681.902
Total Return -Total Cost							229.687
Production Year Cost/Acre							282.539
Production Year Return/Acre							379.433
Production Year (Return - Cost)/Acre							96.894
Establishment Net Return/Productive Acre							39.472
(Total Return -Total Cost)/Acre							57.422

Market Value Method

The market value method allocates preproductive costs based on the market value of the preproductive investment in the multiyear enterprise. Market values are usually measured in terms of purchase prices for replacement animals in the case of dairy or breeding livestock enterprises. Total costs are then computed using equation 10.8. If there is an active market for the leasing of these assets, the annual lease payment could be used instead of $\sum_{j=k} \left((1+\pi)V_0^j - V_1^j\right)$. These costs can then be allocated on a per head basis to producing animals in the herd. For example, in using purchase and sales values, there may be .35 purchases of replacement gilts and .34 sales of cull sows for each sow in the herd. For multiyear crops, market value might be estimated by determining annual lease rates for productive crops. The market value method is similar to the current cost method in that revenue is included for the sales with value of V_1^j. Rather than including the costs of producing the asset in the term $\sum_{j=1}^{m} C_1^j$, as with the current cost method, the cost of purchasing the asset from the market is used.

The market value method is particularly appealing for livestock because it accounts for opportunity costs that may be lost through foregone replacement animal sales. It is also easy to compute. A replacement rate can be used to allocate the market values of replacement animals over the base herd or flock. If one is trying to reflect the profit of alternative enterprises on the farm, using the market value of replacements credits each enterprise (say, heifer production and the dairy herd) with the "appropriate" return and cost. Hence it can be used at any time, preproduction or later.

There are some problems in using the market value method for handling preproductive costs. Markets for replacement animals or multiyear crop leases may not exist in all locations, or there may be unusual price movements due to thin markets. Furthermore, current market values may not cover all the costs incurred in producing the multiyear assets, or may be distorted to reflect future earnings as opposed to historical costs. This may not be as much of a concern in a long-run projected budget. The market value method does not account for the time value of money during the life of the enterprise. Specifically, the cost of purchasing an asset this period is charged against the output from an asset purchased in prior periods. And sales of assets purchased in prior periods are evenly credited to all assets in use this period rather than to just the ones actually sold. As with the current value method, this method represents the costs of a long-run equilibrium situation that is not concerned with the initial start-up costs. Finally, as with the current cost method, determining the actual replacement rate to use to adjust the purchase cost of replacements is difficult. In the case of crop enterprises, separating the value of crop enterprises from land is difficult in estimating market values, often requiring a number of assumptions (Casler and White).

Historic Cost Method

The historic cost method is related to both the current cost and market value methods. As with the market value method, $\sum_{j=k} (1+\pi)V_0^j$ is included to represent the cost of productive assets and $\sum_{j=k} -V_1^j$ is included to account for revenue from current asset sales. Rather than using the market value of these assets, the cost of producing the asset is used to compute $\sum_{j=k} (1+\pi) V_0^j$. The historic cost method is very similar to the current cost method in that the costs of producing replacement assets (livestock) are included explicitly in the cost equation. But the historic cost method uses the cost of producing the replacements that actually enter the operation this year, some of which may have been incurred in prior years, whereas the current cost method includes the costs of assets being produced this year, many of which will not enter the productive operation until future periods. The historic cost method is a reasonable alternative to use when good data on market values are not available. The historic cost method is sometimes called the **raised value method** to emphasize that the cost of raising (producing) replacements, as opposed to their opportunity cost as valued by the market, is being used.

Recommendation

The use of market values is generally preferred to the current cost or historic value methods. The market value of the asset better reflects the opportunity cost of the expenditure. The historic cost (raised value) method is preferred for historical budgets as compared to the current cost method whereas the current cost method is more appropriate for projected budgets. The capital recovery method using market values is preferred to the market value method because the market value method does not account for the time value of money and the fact that most assets are held more than one period. All of the "equilibrium" methods suffer from this same criticism. The main advantages of the current cost, historic cost, and market value methods are ease of use and the explicit accounting for asset purchase (transfer from within operation) and sale (cull or otherwise).

Table 10.5 Allocation of Costs and Revenues for Almonds

		Year	Inflation rate between years	Nominal i between years
Annual real interest	0.040000	0	0.000	0.0400
Annual inflation rate	0.048077	1	0.000	0.0400
Annual nominal i	0.090000	2	0.000	0.0400
Total productive life	25	3	0.000	0.0400
Productive period	19	4	0.000	0.0400
Annual return	2,025.00	5	0.000	0.0400
Annual cost	1,675.00	6	0.000	0.0400
PV(0) or PPC	4,494.6685	7	**0.048077**	0.0900
Salvage	0.00	8	0.000	0.0400
Real Annuity for PPC	342.2179			

	1	2	3	4	5	6	7	8	9	10	11	12	13
Year	Annual Costs end j[2] ne 7$[3]	Amortized preproductive costs end j ne 7$	Annual return end j ne 7$	R[1] end 1 ne 7$ no annuity	Disc R end 0 ne 7$ no annuity	Disc R end 6 ne 7$ no annuity	Disc R end 7 ne 7$ no annuity	Net return end j ne 7$ annuity	Disc R end 0 ne 7$ annuity	Disc R end 6 ne 7$ annuity	Disc R end 7 ne 7$ annuity	Annuity value all years ne 7$	Disc Ann end 0 ne 7$
1	1,895.00			-1,895.00	-1,822.115	-2,305.557	-2,513.057					5.171	5.171
2	718.00			-718.000	-663.831	-839.958	-915.555					5.171	4.972
3	788.00			-788.000	-700.529	-886.393	-966.168					5.171	4.781
4	600.00			-600.000	-512.883	-648.960	-707.366					5.171	4.597
5	70.00			-70.000	-57.535	-72.800	-79.352					5.171	4.420
6	-259.00			259.000	204.691	259.000	282.310					5.171	4.250
7	1,755.53	358.6706	2,122.356	366.827	265.971	336.538	366.827	8.156	5.914	7.483	8.156	5.419	4.087
8	1,755.53	358.6706	2,122.356	366.827	255.742	323.595	352.718	8.156	5.686	7.195	7.843	5.419	3.929
9	1,755.53	358.6706	2,122.356	366.827	245.905	311.149	339.152	8.156	5.468	6.918	7.541	5.419	3.778

TABLE 10.5 (continued)

Year	1 Annual Costs end j ne 7$	2 Amortized preproductive costs end j ne 7$	3 Annual return end j ne 7$	4 R end 1 ne 7$ no annuity	5 Disc R end 0 ne 7$ no annuity	6 Disc R end 6 ne 7$ no annuity	7 Disc R end 7 ne 7$ no annuity	8 Net return end j ne 7$ annuity	9 Disc R end 0 ne 7$ annuity	10 Disc R end 6 ne 7$ annuity	11 Disc R end 7 ne 7$ annuity	12 Annuity value all years ne 7$	13 Disc Ann end 0 ne 7$
10	1,755.53	358.6706	2,122.356	366.827	236.447	299.181	326.108	8.156	5.257	6.652	7.251	5.419	3.633
11	1,755.53	358.6706	2,122.356	366.827	227.353	287.674	313.565	8.156	5.055	6.396	6.972	5.419	3.493
12	1,755.53	358.6706	2,122.356	366.827	218.609	276.610	301.505	8.156	4.861	6.150	6.704	5.419	3.359
13	1,755.53	358.6706	2,122.356	366.827	210.201	265.971	289.909	8.156	4.674	5.914	6.446	5.419	3.230
14	1,755.53	358.6706	2,122.356	366.827	202.116	255.742	278.758	8.156	4.494	5.686	6.198	5.419	3.105
15	1,755.53	358.6706	2,122.356	366.827	194.343	245.905	268.037	8.156	4.321	5.468	5.960	5.419	2.986
16	1,755.53	358.6706	2,122.356	366.827	186.868	236.447	257.728	8.156	4.155	5.257	5.731	5.419	2.871
17	1,755.53	358.6706	2,122.356	366.827	179.681	227.353	247.815	8.156	3.995	5.055	5.510	5.419	2.761
18	1,755.53	358.6706	2,122.356	366.827	172.770	218.609	238.284	8.156	3.841	4.861	5.298	5.419	2.655
19	1,755.53	358.6706	2,122.356	366.827	166.125	210.201	229.119	8.156	3.694	4.674	5.094	5.419	2.552
20	1,755.53	358.6706	2,122.356	366.827	159.735	202.116	220.307	8.156	3.552	4.494	4.898	5.419	2.454
21	1,755.53	358.6706	2,122.356	366.827	153.592	194.343	211.833	8.156	3.415	4.321	4.710	5.419	2.360
22	1,755.53	358.6706	2,122.356	366.827	147.684	186.868	203.686	8.156	3.284	4.155	4.529	5.419	2.269
23	1,755.53	358.6706	2,122.356	366.827	142.004	179.681	195.852	8.156	3.157	3.995	4.355	5.419	2.182
24	1,755.53	358.6706	2,122.356	366.827	136.543	172.770	188.319	8.156	3.036	3.841	4.187	5.419	2.098
25	1,755.53	358.6706	2,122.356	366.827	131.291	166.125	181.076	8.156	2.919	3.694	4.026	5.419	2.017
PV(0)[4]					**80.7783**				**80.7783**				
PV(1)													84.0094
PV(6)						**102.2103**				**102.2103**			
PV(7)							**111.4092**				**111.4092**		
$US_0(r,25)$[5]	15.62208												
CSC(1)[6]	5.1707746												

[1]R = net return
[2]end j = valued at the end of year j
[3]ne 7$ = uses the end of period 7 as the base for real calculations so the real and nominal rates are equal at this point
[4]PV(J) Present value in year J
[5]US_0(r, 25) Uniform series having interest rate r and 25 periods
[6]CSC(1) Capital service cost calculated as the equivalent annual annuity at the end of year 1

Examples of Methods to Allocate Preproduction Costs: Dairy Cow Replacements

Four alternative methods of allocating the costs of raising or acquiring replacement heifers for dairy cows are illustrated in this section. The real price of replacement heifers at the end of the year is assumed to be $1,050, while the real price of cull cows is assumed to be $46.4 per cwt. A cull cow is assumed to weigh 1,200 pounds. Death loss over a 2.5-year productive life is assumed to be 2.5% for a net sales weight of 1,170 pounds (11.7 cwt). This gives a real sales value of $542.88. The 2.5-year life implies a replacement rate of 0.40. The cost recovery, market value, current cost, and historic cost methods are illustrated. All methods and the resulting analysis presented in Table 10.6 are based on the dairy farm example developed in Chapters 13 and 14 of the Task Force report and the CAR estimates presented in Appendix 13A. Milk, revenue, feed, and other costs are the same in all methods.

The first method discussed is the capital recovery cost (annuity) approach. The real price for a purchased heifer of $1,050 less the cull value of the milk cow ($542.88) must be allocated over the economic life of the cow, which is assumed to be 2.5 years. Using equation 10.6, a 2.5-year life, and a 5% real interest rate, the annual replacement cost of the cow is as follows:

$$A_{CR} = \frac{\left(1,050 - \dfrac{542.88}{(1.05)^{2.5}}\right)}{\left(\dfrac{1 - \dfrac{1}{(1.05)^{2.5}}}{.05}\right)}$$

$$= \frac{(1,050 - 480.5412)}{(2.296597)}$$

$$= 247.9576 .$$

This is a real value applicable at the end of the year because PPC (1,050) and SV (522.88) are in end-of-period dollars. No cull income is included in total receipts because this would double count the cull value of the cow. No cost for a replacement heifer is included because this cost is also included in the capital recovery payment. Revenue, feed, and other costs are the same as in the market value and raised value methods. The net return per cow is $190.88.

The second method of allocating replacement costs among the milk cows is to use as the opportunity cost of the heifer, the market price at which it could be bought or sold. This cost is allocated among milk cows based on the replacement percentage of 40% and a cull percentage (with death loss) of 39%. The average nominal cull price taken from Table 13A.5 is $45.56 assuming equal sales each month. This gives cull receipts of $213.22 [(12 cwt/cow)(.39 cows)($45.56/cwt)]. The replacement heifer is assumed to be purchased at a real end-of-year price of $1,050. This is equivalent to an average nominal price of $1,031.36 over the 12-month period as shown in Tables 13A.2 and 13A.8. Revenue, feed, and other costs are the same as in the capital recovery and raised cost methods. The livestock investment cost ($r(1+\pi)V_0^n$) is based on the traditional method to value opportunity cost. We first compute an average inventory value in real terms as

$$\text{Average } V_0^r = \left(\frac{1,050 + 542.88 + 202.848}{2} \right) = \$897.864$$

where \$202.848 is straight-line depreciation over 2.5 years. We can convert this average value to beginning-of-year nominal terms by dividing it by $(1 + \pi)$ to obtain \$863.33 $[(897.864)(1.04)^{-1}]$. Opportunity interest is then computed as [(863.33)(0.05)] = \$43.1665. Adjusting this to end-of-the-year prices will give \$44.8932 [(43.1665)(1.04)]. We could also compute this directly as [(897.864)(0.04)]. The net return using this method which adds revenue for cull sales, adds cost for the purchase of a replacement heifer, and only includes the opportunity interest for one year on the average value of livestock investment is \$186.55 as reported in the last row of Table 10.6.

The third method is the historic cost method, which uses the cost of producing a heifer in the herd as a proxy for the market value of a replacement. Based on the estimates in Table 13A.5A, the cost of raising a heifer to one year of age in end-of-year dollars is \$577.67 and the cost of raising the heifer during the second year (Table 13A.5B) until freshening is \$554.16. Given the 2-year lag in production, this gives a total real cost as of year end of \$1,160.71 [(577.67)(1.05)+554.16] compared to \$1,050 in the case of a market replacement. This translates into a nominal average price of \$1,140.10 as computed in Table 13A.8. Multiplying by the replacement rate of 0.40 gives the net purchase price of \$456.04 [(1,140.10)(0.4)] compared to \$412.54 in the market value case. Revenue is the same as with the market value and capital recovery methods. Feed and other costs for this enterprise budget are the same as with the market value and capital recovery methods. The net returns are \$137.38 per cow. This reflects the higher cost of raising as opposed to purchasing the replacement heifer.

The fourth method considered is the current cost method, which allocates all costs associated with raising replacement heifers to the dairy cow enterprise as direct costs of production. These estimates are developed using the costs of raising a heifer in Tables 13A.5AB, 13A.6AB and 13A.7. The costs of raising a heifer from birth to one year of age are in Tables 13A.5A and 13A.6A; the costs of raising a heifer from one year of age until freshening are in Tables 13A.5B and 13A.6B. The current cost method assumes a continuous inventory of replacement animals and so Table 13A.7 presents the combined costs of having both the first and second year replacement animal in the herd. Given the replacement rate of 40%, 40% of these costs are added to the costs of the milk cow instead of the cost of a replacement heifer. This method also assumes that almost all the female calves are used for the replacement activity and so sales are minimal. Feed costs, other variable costs, and fixed costs reflect both the costs associated with the dairy cow and those associated with her share of all replacements on the farm. Total farm costs are allocated on a per cow in the herd basis. There should be little difference between the historic cost and current cost methods except for the assessing of interest charges on the historic costs of raising the replacement, and any price level differences between the current and previous years. In this case the cost per cow is \$149.92.

TABLE 10.6 Different Methods of Allocating Heifer Costs in a Dairy Cow Budget (values in $/cow)				
	Capital recovery	Market value	Historic value	Current cost
Item				
Revenue				
Milk Sales	2,652.04	2,652.04	2,652.04	2,652.04
Cull Sales	0.00	213.22	213.22	213.22
Bull Calf Sales	51.00	51.00	51.00	51.00
Heifer Calf Sales	61.20	61.20	61.20	2.27
Interest on Revenue	113.44	122.37	122.37	119.94
Total Receipts	2,877.68	3,099.83	3,099.83	3,038.47
Operating Costs				
Replacement Cost	0.00	412.54	456.04	0.00
Feed Cost	880.40	880.40	880.40	1,053.22
Other Operating Costs	699.39	699.39	699.39	776.06
Interest on All Operating Costs	65.09	82.08	83.87	75.37
Total Operating Costs	1,644.87	2,074.41	2,119.70	1,904.65
Allocated Overhead				
Labor Costs	522.42	522.42	522.42	602.23
Livestock Investment	247.96	44.89	48.77	60.32
Other Fixed Costs	271.55	271.55	271.55	321.35
Total Allocated Overhead	1,041.93	838.87	842.74	983.90
Total Costs	2,686.80	2,913.28	2,962.44	2,888.54
Net Returns	190.88	186.55	137.38	149.92

An examination of the net returns using the four methods in Table 10.6 indicates little difference among the methods. Any difference would depend on the relationship between current costs of heifer production, historic costs of heifer production, and the market value for fresh heifers.

RECOMMENDATIONS

Based on the relative advantages and disadvantages of each of the four approaches discussed, and given the nature of the production process for multiyear crop and livestock enterprises, the following recommendations are made for estimating and allocating preproductive costs.

The Task Force recommends that the cost recovery approach be used in preparation of projected CAR for multiyear crop enterprises. It overcomes the shortcomings of the traditional budgeting method, and provides an intuitive approach for allocating

establishment costs on an annualized basis. It is particularly well-suited for CAR estimates constructed for management purposes. The cost recovery approach can also be used for historical estimates but may require more data than is typically available from farm records. Therefore historical CAR estimates for multiyear crop enterprises, developed primarily to record economic costs incurred during a given year, may be constructed using the current cost method to reflect the input and price levels actually experienced.

The cost recovery approach is also the recommended method to estimate replacement costs included in projected CARs for multiyear livestock enterprises. This method is preferred for all projected livestock CAR estimates, regardless of their purpose. This method appropriately handles the costs of replacement animals and accounts for the time value of money in reasonable manner. If breeding stock or milking stock are replaced by purchasing replacement animals, the cost of the replacement animals should be allocated over the productive life of the breeding animals using capital recovery. Expenses associated with raising replacement animals can be distributed in the same manner. The market value method, when markets for replacement animals are reasonably well developed, and the current cost method, when markets for replacements are thin, provide a reasonable alternative in situations where it isn't feasible to apply the cost recovery method in preparing projected CARs. Historical CARs for livestock, constructed primarily to record economic costs incurred during a production period, should use the market value method when markets are well developed and data allows the separation of the replacement animal enterprise from the production enterprise. In other situations, the current cost method may be used.

Format of Reports

The Task Force recommends that multiyear crop enterprise preproductive costs be reported in the same format used for single-year enterprises. A report of the annual preproductive costs for each year of the preproductive period should be included in the CAR estimate. Annual cost recovery expenses, calculated using equation 10.6, should be included in production year budgets. Assumptions about discount rates, productive lives, and salvage values of multiyear crop enterprises should also be specified in production year CAR estimates.

The Task Force recommends that livestock establishment costs and historical multiyear crop cost estimates be reported in the same report as the nonestablishment annual costs. Assumptions or data gathered concerning replacement or replanting rates should be reported as well, to provide users with information about rates of "establishment."

COMPARING ANNUAL ENTERPRISES TO MULTIYEAR ENTERPRISES

Users of CAR estimates often compare returns among two or more enterprises. If all of the enterprises are annual, then a comparison of CAR estimates adjusted to year-end values is valid, assuming each CAR estimate is constructed in a consistent manner. (See the international comparisons chapter for a discussion of other issues surrounding CAR estimate comparisons.) However, if annual enterprise CAR estimates are compared to multiyear CAR estimates, a problem arises. Capital budgeting procedures have shown that two projects or investments with unequal lives can only be fairly compared when they are evaluated over an equivalent life (Copeland and Weston). This same reasoning applies to comparisons of enterprises with different productive time periods.

Cost and return estimates are converted to equivalent lives using the equivalent annual annuity approach, which is a 2-step process. First, the net present value (NPV) of each enterprise is calculated by discounting annual returns over the productive life of the enterprise using a real interest rate. Second, an equivalent annual annuity of each crop is calculated by dividing the net present value by the appropriate annuity factor to get an annual payment for comparison.

Estimating Net Present Value

Cost and return estimates for annual crops are expressed as net (returns minus costs) present values at the end of the production period, so no adjustments are necessary for these enterprises. Multiyear enterprises have production costs expressed in values as of the end of each production year, and these CARs occur at some point in the future or the past. Projected CARs must be discounted over the life of multiyear enterprises to estimate annual net returns comparable to returns from annual enterprises.

If the cost recovery approach is used to estimate annualized preproductive costs, then the costs of the preproductive period are accounted for in the CAR estimates for productive years of multiyear enterprises. The net present value of a multiyear enterprise at the end of the first year of its productive life is calculated as

$$PV(J+1) = \sum_{k=J+1}^{N} R_k (1+r)^{1-k+J} \qquad \textbf{(10.10)}$$

where R_k is the annual net return for the enterprise in year k after subtracting all costs of production, including A_{CR} as calculated in equation 10.6. It is often assumed that R_k is constant for all production years of the enterprise and denoted by R. For the almond example in Table 10.5, the real value of annual gross returns at the beginning of year 7 (actual production period) is assumed to be \$2,025. With inflation of 4.8077% this gives an end-of-year value of \$2,122.356 for year 7 and all years thereafter. Recall that J is the total years in the preproductive period and N is the years of life of the enterprise. If we want to discount this value to the beginning of the first productive period we must do so using the nominal interest rate because current year CARs are expressed in nominal dollars relative to the end of the period. This will give

$$PV(J) = \frac{\sum_{k=J+1}^{N} R_k (1+r)^{1-k+J}}{(1+i)} = \sum_{k=J+1}^{N} R_k (1+r)^{1-k+J} (1+i)^{-1} . \qquad \textbf{(10.11)}$$

Using the almond enterprise as an example with a real interest rate of 4% and no assumed inflation over the productive life of the trees, N = 25, J = 6, real returns in years 7-25 equal to \$2,025.00 per year, annual costs (in real terms) in years 7-25 of \$1,675, and real amortized preproductive costs equal to \$342.2179, we can compute R_k (k=7,8,...,25) as = \$7.7821[2,025-1,675-342.2179]. With inflation in year 7 of 4.8077%, this net return is equal to \$8.1563 as reported in column 8 of Table 10.5. PV(7) is estimated to be \$106.2987 at the end of the first productive year (year 7) of the almond enterprise and \$102.2103 [(106.2987)/(1.04)] at the beginning of the year 7 assuming that r=i in all years including the seventh. If, on the other hand, it is assumed that π = 4.8077% during the seventh year, then all CARs in this year must be adjusted. The annual cost of \$1,675 becomes \$1,755.53 [(1,675)(1.048077)] as in column 1 of Table 10.5, the real annuity of 342.2179 becomes \$358.67063, and annual returns are inflated to \$2,122.356. The present value at the end of the seventh year (PV(7)) is now estimated to be 111.4092 (column 11) with a value at the beginning of the year of [(111.4092)/(1.09)] 102.2103 (column 10) as before. We can also compute the value of these income streams at the beginning of the first period. This is done using equation 10.8, which discounts all net returns to the beginning of the first period assuming that inflation occurs only in period 7.

$$PV(0) = \frac{\sum_{k=J+1}^{N} R_k (1+r)^{1-k}}{(1+i)} = \sum_{k=J+1}^{N} R_k (1+r)^{1-k} (1+i)^{-1} . \qquad \textbf{(10.12)}$$

For the almond example this gives a net present value at the end of the 0^{th} period of 80.778 [102.21030/(1.04)^6] as reported in column 9. The discounted returns for each year over the entire life of the orchard are reported in columns 5-7 of Table 10.5. These columns allocate preproductive costs to preproductive years and operating costs to productive years. Thus these columns have large negative returns in the preproductive years and much higher net returns in the production years compared to columns 9-11 where returns and costs are zero in the preproduction years. Notice that the net present value of returns in columns 5-7 are the same as those in columns 9-11 (where the preproductive costs are accounted for as an annuity).

Converting to Equivalent Annual Annuity

The final step required to enable comparison of enterprises with unequal lives is to convert each enterprise's NPV to an equivalent annual annuity. An annual equivalent is a constant return which, when summed over the total life of the enterprise, is equal to the net present value of the returns from the enterprise. An equivalent annual annuity is assumed to be received during every year of the enterprise's life, **including all preproductive and productive years**.

The formula used to calculate an equivalent annual real annuity (EAA) is given in equations 2.31, 6.8, and 2B.6 where the numerator is now PV.

$$EAA = \frac{PV}{\sum_{k=1}^{N} (1+r)^{-k}} = \frac{PV}{US_0(r,N)} = \frac{PV}{\left(\frac{1 - \frac{1}{(1+r)^N}}{r}\right)}. \qquad \textbf{(10.13)}$$

This is the real payment made at the end of each of the periods of the enterprise life that has the same present value as the actual return stream calculated in 10.12. Using equation 10.13 for the almond enterprise with an estimated PV of $80.778 results in an EAA value of $5.17077. This means that establishment and production of almonds over a 25-year period yields a return equivalent to $5.17077 at the end of each year of the orchard's life. This value is reported in column 12 of Table 10.5. Because there is inflation of 4.8077% in year 7, the value is 5.41937 in years 7 and beyond. The net present value of this annuity at the beginning of year 1 is 80.77825, as expected. This value of almond returns can be compared to CAR estimates for annual enterprises or to equivalent annuity estimates for other multiyear enterprises.

APPENDIX 10A

Data on Almond Production

Sample Costs per Acre to Establish an Almond Orchard – 1992
California – Northern San Joaquin Valley

Labor rate: $10.72/hr. machine labor — Interest rate: 9.0%

$6.70/hr. non-machine labor — Trees/Acre: 75

	Costs per Acre					
YEAR	1st	2nd	3rd	4th	5th	6th
YIELD (Meat Pounds/Acre)				500	1,200	1,600
Planting costs:						
Land Preparation - Backhoe (8 holes per hour)	351					
Fumigate - Custom Application	492	3	1			
Disk and Float - 2X	17					
Trees: 75 @ $3.80 (+2 2nd Yr. And 1 3rd Yr.)	285	8	4			
Survey and Plant Trees	75	2	1			
TOTAL PLANTING COSTS	$1,220	$13	$6			
Cultural costs:						
Prune and Train		$19	$25	$37	$74	$74
Irrigate	$33	33	33	33	33	33
Fertilizer and Application	16	21	31	47	57	66
Pest Control - Dormant		29	46	46	46	46
Pest Control - Pinkbud				33	33	33
Pest Control - Shothole/Nutrient		16	19	40	40	40
Pest Control - Worm/Mite	14	19	23	57	57	57
Cultivate - 4X	10	10				
Mow Centers - 7X			33	33	33	33
Weed Control - Winter Strip	67	67	67	67	67	67

Weed Control - Spring Spot			13	13	13	13
Weed Control - Preharvest				10	10	10
Pollination				30	60	60
Miscellaneous Costs	23	23	23	23	23	23
Pickup Truck Use	56	56	56	56	56	56
TOTAL CULTURAL COSTS	$219	$293	$369	$525	$602	$611
Harvesting costs:						
Shake				90	90	90
Pole					7	9
Sweep				7	16	21
Hand Rake				2	2	2
Pickup and Haul				26	63	97
Hull and Shell				25	60	80
TOTAL HARVEST COSTS				$150	$238	$299
Interest on operating capital @ 9%	53	9	10	22	27	28

U.C. Cooperative Extension

	Costs per Acre					
YEAR	1st	2nd	3rd	4th	5th	6th
Overhead costs:						
Office Expense	30	30	30	30	30	30
Almond Board of CA Assessment Fee				11	27	36
Leaf Analysis Fee	5	5	5	5	5	5
Property Taxes	61	61	61	61	61	61
Equipment Insurance	31	31	31	31	31	31
Investment Repairs	4	4	4	4	4	4
TOTAL OVERHEAD COSTS	$131	$131	$131	$142	$158	$167
TOTAL CASH COSTS	$1,560	$383	$453	$765	$935	$1,006
INCOME FROM PRODUCTION				$500	$1,200	$1,600
NET CASH COSTS FOR THE YEAR	$1,560	$383	$453	$265		
PROFIT ABOVE CASH COSTS					$265	$594
TOTAL ACCUMULATED NET CASH COSTS	$1,560	$1,943	$2,396	$2,661	$2,396	$1,802
Depreciation:						
Buildings	14	14	14	14	14	14
Flood Irrigation System	19	19	19	19	19	19
Fuel Tanks & Pumps	4	4	4	4	4	4
Shop Tools	7	7	7	7	7	7
Equipment	44	44	44	44	44	44
TOTAL DEPRECIATION	$88	$88	$88	$88	$88	$88
Interest on investment @ 4%						
Buildings	9	9	9	9	9	9
Flood Irrigation System	10	10	10	10	10	10
Fuel Tanks & Pumps	2	2	2	2	2	2
Shop Tools	3	3	3	3	3	3

Land @ $5263/acre	211	211	211	211	211	211
Equipment	12	12	12	12	12	12
TOTAL INTEREST ON INVESTMENT	$247	$247	$247	$247	$247	$247
TOTAL COST FOR THE YEAR	$1,895	$718	$788	$1,100	$1,270	$1,341
INCOME FROM PRODUCTION				$500	$1,200	$1,600
TOTAL NET COST FOR THE YEAR	$1,895	$718	$788	$600	$70	
NET PROFIT ABOVE TOTAL COST						$259
TOTAL ACCUMULATED NET COST	$1,895	$2,613	$3,401	$4,001	$4,071	$3,812

Source: University of California, Cooperative Extension, Department of Agricultural and Resource Economics.

APPENDIX 10B

Allocating Preproductive Costs with the User Cost Method

Managers frequently face decisions on when to replace depreciable assets, but it is a controversial topic. The basic problem is that all of the standard methods in use require a forecast of the price of the output that is produced while using the asset, unless output is constant and unaffected by age of the asset. For example, in the case of a peach orchard, the usual discounted cash flow methods require a forecast of peach prices for each year over the expected life of the trees. Controversy arises over the validity of price forecasts no matter how those forecasts are made. The method presented here avoids this problem by not using price forecasts, but instead only known historical cost data. The method can be attributed to the article by Harold Hotelling. The criterion for replacement is "minimum unit cost." In other words, the age of replacement is chosen so as to minimize the cost of production per unit of output. An application to cling peach orchards is given here to explain and illustrate the method. Sequential fine tuning of the replacement decision in the face of price uncertainty is also provided.

Replacement Decision Method

All replacement decision methods begin by evaluating the expected productivity of an asset over its life. The typical yield pattern by age of trees for late maturing peach varieties is given in 10B.1, which was constructed from the California Cling Peach Advisory Board's "Orchard Production Survey, 1994-95." Yields are zero the first two years after planting and then increase steadily, reaching a maximum of 22 tons in the ninth year of age, where yields start declining steadily to about 12.5 tons by age 25. Initial establishment of the orchard requires quite a large outlay that is followed by two years without revenue and some additional costs before revenues begin, which makes peach production a long term, capital-intensive investment. An important economic question is: What is the optimal age at which the orchard should be replaced, or the land devoted to another use? This question is answered below by applying Hotelling's minimum unit cost criterion.

Investing land and capital in the production of an orchard crop is intended to generate a cash flow from that crop. A large part of the investment's total cost is the interest expense associated with the money tied up in land and capital. The primary nonland investment is establishment costs incurred before the trees begin to bear fruit. Cash flow costs are annual outlays associated with caring for the trees, cultural costs, and harvest costs. The general idea behind the unit cost criterion for replacement is to calculate the cost per unit of output (peaches in this example) for a given replacement age, and through a search over various replacement ages, choose the age that has the smallest cost associated with it. If all costs (including fixed costs, management, and such nebulous things as a margin for risk that do not affect optimal replacement age) were taken into account, a price per unit of output just equal to this minimum cost, which will now be referred to as "unit cost," would allow the firm to just break even in the production of peaches. Thus, the objective is to choose the replacement age which minimizes the cost per unit of output and, therefore, obtain the largest profit margin.

The value of land is treated as the initial investment cost, and this cost is recovered at the end of the orchard's economic life. Establishment costs for the orchard are put into the first year's annual cost category. Establishment costs could be included with land value, but then their depreciated value of zero at replacement would need to be recognized. Salvage value of the orchard investment is the net market value of the old trees, which could be either positive or negative, plus the value of land which would suffer no depreciation over the life of the orchard, with few exceptions.

It is necessary to define some special notation in order to make the definition of the minimum unit cost criterion for replacement unambiguous. The following definitions will be used, where the subscript j on a letter denotes the j^{th} year in the life of the asset:

C_j = annual cost associated with an asset of age j
Q_j = quantity of output from the asset at age j
r = replacement age
V_0 = initial investment cost of the asset
V_n = salvage value of the investment if replaced at age n
r = the real rate of interest expressed in decimal form.

A dollar value received t years in the future is transformed into an amount that is comparable to a dollar received now by dividing the future amount by $(1+r)^t$. For example, with an interest rate of five percent, \$10 received two years from now would at present be worth $\frac{\$10}{(1+r)(1+r)} = \frac{\$10}{(1.05)^2} = \$9.07$.

The unit cost equation described earlier in words can now be written as

$$\frac{uQ_1 - C_1}{(1+r)} + \frac{uQ_2 - C_2}{(1+r)^2} + \ldots\ldots \frac{uQ_n - C_n}{(1+r)^n} + \frac{V_n}{(1+r)^n} = V_0 .$$

Solution of the above equation for the unit cost variable u gives the formula,

$$u = \frac{V_0 - \frac{V_n}{(1+r)^n} + \frac{C_1}{(1+r)} + \frac{C_2}{(1+r)^2} \ldots\ldots + \frac{C_n}{(1+r)^n}}{\frac{Q_1}{(1+r)} + \frac{Q_2}{(1+r)^2} + \ldots\ldots + \frac{Q_n}{(1+r)^n}} .$$

One obtains the minimum unit cost replacement age by searching over a set of values for n that is expected to include the optimal replacement age, and the smallest value of u indicates the optimal choice of n for replacement age. The procedure is illustrated below in a cling peach orchard example.

Cling Peach Orchard Replacement Results

Estimates of the costs and physical relationships summarized above were made for a small peach orchard in the Southern San Joaquin Valley. Estimates of annual costs and peach yields (tons/acre) in relation to age of the orchard are given in Table 10B.1, columns 2 and 3, respectively. Salvage value of the orchard itself is approximated as zero (excluding the land value at that time). Therefore, salvage value V_n in the formula for unit cost is the value of land at the time of replacement, which is taken to be equal $5,500, the same value used for the investment cost of land at the time the initial orchard is planted. The real rate of interest used is 5%. This is all the data that is needed to apply the unit cost criterion for optimal replacement of the peach orchard.

The cost of producing a ton of peaches is given in the last column of Table 10B.1 for each replacement age. The lowest is achieved with replacement at 15 years, and this result does not change if land value is between $2,000 and $10,000 per acre. With land price at $500 to just under $2,000, the optimal replacement age is 14 years, while a land value of $25,000 calls for replacement at 18 years. The economic intuition underlying this result is that the high interest costs accompanied by low yields early in the yield cycle must be compensated by holding the orchard longer even though yields are decreasing considerably between ages 15 and 18. Modest changes in the salvage value of the old orchard, up or down by $500, did not alter the replacement age from 15 years.

As expected, the best replacement age was quite sensitive to interest rate changes, as shown in Table 10B.2. For example, the best replacement age changed from 15 to 17 years when the interest rate was doubled from 5% to 10%, and another doubling of the rate from 10% to 20% increased the optimal replacement age to 22 years. But moving the interest rate down from 5% to 0% only lowered the replacement age from 15 to 14 years. Incidentally, a zero interest rate in the formula for unit cost converts the unit cost formula into average cost per unit of output, which is quite an intuitive criterion when the business does not have to bear any interest costs, either explicit or implicit, through opportunity cost of the farm's own funds.

Although the optimal replacement is changed by altering the interest rate and other economic factors involved in unit cost measurement, replacing the orchard three years too early or late increases cost per ton of peaches by only a dollar or two (see the last column in Table 10B.1). Mistakes in the direction of too short a period are more costly than keeping the orchard too long, e.g., replacing the orchard after 25 years (a 10-year error) gives a cost of $98 per ton instead of the minimum of $492, while replacement at age 10 (a 5-year error) gives the same cost of $498 per ton. Since the unit cost of peach production is so insensitive to modest variations in replacement age similar to those estimated here, peach producers should feel comfortable using 15 years as a "rule of thumb" replacement age for their orchards.

The insensitivity of unit cost to delaying the replacement age of a peach orchard by as much as even ten years from the least cost age provides the producer great flexibility to delay replacement if peach price expectations are relatively high for the near future. Replacement of an acreage of peaches results in almost zero production for three years, making it economically attractive to postpone replacement until price expectations decline to what is thought of as more nearly normal levels. This observation also suggests that a risk averse producer would be included to diversify by synchronizing various aged stands to provide a fairly constant supply of fruit. Nevertheless, the astute producer would probably deviate from the nearly even aged stands goal to exploit short-run output price dynamics. Data on aggregate acreage response to changing prices by cling peach growers suggest a tendency to diversify by avoiding heavy concentrations of trees of the same age.

TABLE 10B.1 Costs and Yields by Age

Age	Annual Costs (dollars)	Yield (tons/acre)	Unit Cost (dollars)
1	1,972	0	----
2	469	0	----
3	4,372	9.4	841.01
4	6,020	14.0	611.47
5	8,022	17.5	555.00
6	9,106	19.9	529.24
7	9,877	21.4	516.09
8	10,113	22.0	507.74
9	10,152	22.1	502.21
10	10,074	21.9	498.45
11	9,877	21.4	495.91
12	9,606	20.7	494.24
13	9,326	20.0	493.17
14	9,051	19.3	492.53
15	8,736	18.5	492.22
16	8,648	17.8	492.67
17	8,244	17.1	492.90
18	7,999	16.4	493.34
19	7,825	15.7	494.08
20	7,619	15.1	494.93
21	7,339	14.6	495.63
22	7,087	14.0	496.34
23	6,834	13.5	496.98
24	6,635	13.0	497.63
25	6,478	12.6	498.29

TABLE 10B.2 Optimal Replacement Ages

Interest Rate	0	.05	.10	.15	.20
Optimal Age	14	15	17	18	22
Unit Cost ($)	471	492	518	548	586

CHAPTER 11

INTERNATIONAL COMPARISONS

INTRODUCTION

In addition to generating cost and return (CAR) estimates for domestic purposes such as policy analysis, industry monitoring, and farm management extension, there is often a need for analysts to make comparisons with CAR estimates from other countries. Comparison requires that CAR estimates pertain to the producers, after allowing for all CARs associated with getting an identical product to a specific place, at a specific time, and in a specific form.

This section of the Task Force's report deals specifically with the subject of international comparisons. It is organized in four parts. The first part outlines some of the reasons for making international comparisons. The second offers a brief description of potential sources of CAR estimates in other countries. The third addresses the major issues associated with making international comparisons. The fourth and final part presents an example of an international comparison of farm CARs.

REASONS FOR UNDERTAKING INTERNATIONAL COMPARISONS

There are several reasons why agricultural economists might wish to undertake international comparisons of commodity CARs. The first involves intercountry competitiveness studies. In the context of market development, countries might be interested in determining whether or not their producers can compete against the "threat" of imports from another country, or whether they are able to exploit an export opportunity. In the latter case, there is interest in knowing whether producers are competitive not only with domestic production in the importing country, but also with exporters from other countries who could be interested in competing for this same market.

Another reason has to do with assessing how changes in trade policies affecting tariffs, quotas, and domestic support policies might affect the competitive position of producers. For example, in Canada, during the Uruguay round of international trade negotiations, there was considerable concern among producers of protected dairy and poultry products that they would be unable to compete against U.S. producers in the Canadian market following tarrification of the quantitative import controls used to protect these sectors under Canada's supply management system. Comparisons of Canadian and U.S. CARs for milk, eggs, and poultry meat helped to determine how many Canadian producers of these products could have survived had a more liberal trade regime been put in place.

There are a number of caveats that should be noted with regard to intercountry competitiveness studies. First, CARs at the farm level are only part of the competitiveness equation. There is also need to take account of the marketing and transportation costs incurred in moving the product from the farmgate to final destination. Second, competitiveness could vary within a country. In Brazil, for example, domestic corn producers in the interior cannot compete with U.S. imports in deficit coastal regions of the country. The domestic producers, however, are highly competitive in their own surplus production region.

A third reason for undertaking international comparisons of farm CARs is also trade-policy related. A country considering the imposition of countervailing or antidumping duties against imports from another country might wish to examine the costs of production of the commodity in question in the other country, and in particular how those costs are affected by government assistance programs such as input subsidies.

Finally, international comparisons of commodity CARs could be useful information in making investment decisions. For example, if a decision is being made to invest capital in the production of export commodity "X" in country "Y", the decision maker will probably want to know if country "Y" can be cost competitive in export markets, not only with domestic production in the importing country, but also with other exporters competing for that market.

INFORMATION SOURCES FOR INTERNATIONAL COMPARISONS

There are several potential information sources that can be pursued by analysts wishing to undertake international comparisons of CAR estimates between countries.

At the government level, CAR estimates might be available from national and/or provincial/state departments of agriculture including agricultural extension services. Other public sector sources of CAR estimates could include agricultural census or statistical agencies, planning departments, agricultural development banks, university departments of agriculture, and agricultural colleges. Local offices of international development organizations such as The World Bank, the Food and Agriculture Organization of the United Nations (FAO), and the United States Agency for International Development (USAID) could also be sources of CAR estimates.

Potential private sector sources of CAR estimates include producer organizations, agricultural lenders, input suppliers, agricultural cooperatives, and voluntary organizations.

ISSUES ASSOCIATED WITH INTERNATIONAL COMPARISONS

All countries that prepare estimates of commodity CARs are faced with the problems addressed in earlier chapters of this report. These issues are not addressed in this section. Instead, the objective here is to identify the issues that are specific to international comparisons of CARs, and to suggest ways of dealing with them. In other words, what problems should analysts and researchers be aware of in making international comparisons, and what adjustments should they make in order to ensure that the comparative analysis they are undertaking is valid? With the exceptions of exchange rates, interest rates, and inflation, the issues discussed in this section also apply to interregional comparisons of CAR estimates within the same country.

Terminologies, Definitions, and Concepts

Different countries (and institutions within a country) use different concepts, definitions, terminologies, and measurement methods to estimate their commodity CARs. They also use different formats to present their data. A few examples will serve to illustrate the point. In enterprise cost of production studies undertaken in the United Kingdom, the difference between the value of gross output and variable costs is called the gross margin, whereas in Canada gross margin is now defined as the excess of total revenue over the cost of goods sold. The difference between total revenue and variable costs is called the contribution margin. In the United States, the Economic Research Service (ERS) presents its crop CAR estimates from the Agricultural Resource Management Study (ARMS) in terms of gross value of production and cash expenses including general farm overhead. In Canada, Alberta Agriculture presents its crop estimates in terms of gross returns, variable costs including unpaid and operator labor, and capital costs (land rent, taxes, insurance and water rates, depreciation, and paid capital interest). Alberta does not include an allowance for general farm overhead. ARMS does not use data it collects on depreciation for tax purposes to estimate capital costs, but instead computes capital recovery in a manner similar to Chapter 6 based on the equipment used by the various operations. Some of the items that Alberta includes in capital costs are regarded as cash expenses by ARMS. Some institutions go even further. For example, at one time in Canada the costs of egg production estimated by the Canadian Egg Marketing Agency included full allocation of all imputed costs, including a return to operator management.

Analysts undertaking international comparisons must be alert to these conceptual, definitional, and presentational differences. Care must be taken to ensure that the terms and concepts used by other countries are understood fully and that the appropriate adjustments are made to put the estimates in the two (or more) countries on the same basis.

More generally, there is a need for agricultural economists in North America to improve their understanding of how other countries have dealt with the issues being addressed by the Task Force—we might be able to learn something from the experiences of these countries. In this regard, it is worth noting that a Symposium on International Comparisons of Cost of Production was held at the International Association of Agricultural Economists (IAAE) Conference held in Tokyo, Japan in August 1991. The symposium heard from representatives of several countries about how they prepared their commodity CAR estimates. Specific issues relating to comparisons of international cost of production estimates were also addressed.

Policy-Induced Product and Input Price Distortions

Most countries engage in protective or extractive policies that affect input and/or product market prices to some extent. In some cases the price effects can be extreme, and could materially affect cost of production measures. These policies can be related directly to the commodity in question or to an input used in the production process, or they can be general economic policies that indirectly impact input or product prices. In addition, indirect subsidies could exist in the form of transportation and communication systems.

Product or input price distortions affect not only the international cost comparison of individual input items but also the quantity of input use, quantity of output, and form of output. These in turn complicate the measurement and comparison of costs of production between countries.

Examples of common price-distorting policies include commodity price supports (taxes), input subsidies (taxes), border subsidies (tariffs or duties), border quotas, and exchange rate controls. Often, the effect of these policies is cumulative and could cause cost distortions on commodities not affected directly by the policy. For example, during the 1970s and 1980s, the land costs of soybean producers in the United States were influenced heavily by price supports for corn. These land costs were often the residual of a variety of price distortions as farmers bid excess profits (losses) into higher (lower) land rental rates (or prices) which then affected cost of production measurements.

Cost comparisons among Argentina, Brazil, and the United States in soybeans and corn during the 1980s provide dramatic examples of problems associated with policy-induced price distortions. These three countries are the principal competitors in international soybean markets. They have similar yield levels, yet displayed widely differing farm-level costs of production. Contrasting policies were responsible for these differences, and the principal input cost affected was land. In 1986, typical per acre land rents for soybean were $19 in Argentina, $31 in Brazil, and $50 in the United States. At that time, in terms of policies, Argentina taxed agriculture, Brazil was slightly supportive of agriculture, and the United States had strong subsidy support (corn).

Argentinean corn production is a second example of a policy impact on input use, output level and cost of production. Product exports were taxed at rates of 20 to 30%. Punitive exchange rates further taxed exports, and fertilizer imports were taxed. The net results were farm-level corn prices at about two-thirds of U.S. levels, no commercial fertilizer use, yields of about one-half of U.S. levels on comparable soils, extensive crop-livestock rotations that included pasture and forage production, and use of animal and green manure to maintain fertility.

Under similar policy regimes, with comparable soil and climate, similar input and output values would be expected. Yet the policy differences described above changed all that. Given these policy differences, problems in comparing costs of corn production between Argentina and the United States were substantial. For example, some fertility input to the corn crop could be assumed from the Argentinean rotation, yet no fertilizer use was included in the published corn estimate. Land costs (rents) were charged at about 40% of U.S. levels. Based on these estimates, Argentina in the 1980s was viewed as the lowest cost corn producer by a wide margin. Yet corn was not a dominant crop in Argentina and land was extensively cultivated.

In the 1990s price and cost distortion policies in both countries have been relaxed. As a result, cost of production differences between the countries have diminished.

There are several alternative methods of dealing with price-distorting policies in CAR estimates.

1. Estimates can be presented "as is" with the policy-induced price distortions. The estimates would then represent the cost of production conditions currently faced by farmers operating under these country policies. As a minimum, the impact of price-distorting policies should be pointed out to users of comparative estimates. However, in a practical sense there is little a researcher can do to adjust technology or quantities of inputs used that are influenced by policy actions.

2. If land prices are the principal distortion, rents can be eliminated as a cost item and comparisons made on a nonland basis.

3. Some estimate of economic costs as different from financial costs can be attempted for individual input cost items (see the subsection entitled **Financial Accounting Versus Economic CARs**).

Exchange Rates and Inflation

Choosing the appropriate exchange rate and adjusting for inflation are problems common to all intercountry cost of production estimates because all estimates have to be denominated in a common currency at one point in time in order to make accurate comparisons. The dollar is typically the currency of comparison.

Inflation

Price inflation distorts estimates in several ways. It tends to bias nominal net income upward because of the time lag between production costs and receipt of sales revenue, to increase investment in assets which hold value, to create economic uncertainty which discourages long-term investment, and to cause loss of value against foreign currencies.

The question of inflation is particularly troublesome in countries with rapid changes in the value of their currency. In Brazil, for example, where inflation has run at levels exceeding 30% per month, some estimators have attempted to predict inflation rates within a production season and thus use different nominal price estimates at different times of the year. In these cases, the estimates of the various cost items are made for the month in which the expenditure would occur at the estimated nominal market prices for that month. For example, seed, fertilizer, and planting labor are priced in the spring, while harvest labor or harvest custom hire are priced at inflated values for six months later. Similarly, interest rates include an inflation adjustment, and thus could be in the 30 to 50% per month range.

In other situations, quantities of inputs and outputs are presented and prices are updated as appropriate for the time period in question. All prices are generally presented on a specific date. This, of course, is a problem when there is great seasonal variation in prices even when corrected for inflation.

A final method used to circumvent inflation problems is to use a deflated measure or to present the budgets in dollar equivalents. Brazil, for example, has an inflation-neutral measure called an ORTN which is used in commerce agreements. Estimates are sometimes presented in number of ORTNs.

There are several methods to deal with inflation.

1. If nominal input and output prices were used during the production cycle in a high-inflation environment, an effort should be made to adjust all prices and values to a common point in time. This intra-seasonal adjustment can be done using monthly price indexes from the country's government sources. Adjustment requires specification of

input use by month, and assumes that the inputs were purchased in the month they were used.

2. Interseasonal adjustments (e.g., across years) can be accomplished by uniformly adjusting all prices and values in the CAR to the desired point in time using the country's annual and/or monthly price indexes.

3. If the country's price indexes are unavailable or unreliable, linkage to a third-country's price index or currency exchange rate can be used for interseasonal comparisons.

Exchange Rates

Choosing the appropriate exchange rate to use in converting local currency costs to U.S. dollars can be a difficult task. First, there is often more than one exchange rate—an official exchange rate (some countries may have more than one official rate), and a black market exchange rate. Where these rates diverge strongly, the official rate is probably being manipulated by the government for policy purposes.

The dollar is the usual currency of comparison. Its value has varied considerably against other major currencies, especially in recent years. This raises the question of not only the appropriate exchange rate to use, but also the appropriate year(s) in which to select the exchange rate. For cost comparisons with countries that peg their currency to the dollar, changes in the relative value of the dollar will be less important.

There are several methods to consider exchange rates (Valdes et al.).

1. Some researchers use estimation techniques to measure an "equilibrium exchange rate" or "real exchange rate" using variables such as domestic absorption (ratio of domestic expenditure to gross domestic product), terms of trade, commercial policy, ad valorem tariff rates, and public sector wages among others. These efforts typically result in a different level of exchange distortion for each year measured, and are difficult to replicate across countries for lack of data. These estimates are probably beyond the scope of most CAR comparison studies.

2. On a more practical level many international agencies such as The World Bank attempt to measure the degree of over- or undervaluation of specific currencies. For example, for a number of years Brazil was considered to have an official exchange rate that was overvalued by 20%, and economic studies regularly discounted domestic costs by this amount when the official exchange rate was used to convert cruzeiros to dollars.

3. In countries with reasonably stable exchange rates, an average or mean exchange rate over a number of years adjusted by a ratio of domestic deflators can be used to test whether or not an exchange rate for a given year is appropriate.

Exclusions and Unaccounted Costs

It cannot be assumed when comparing the same CAR estimate from different countries that each estimate will contain the same cost items in the same level of detail. Often, the estimates will have no values, or very low (high) relative values for common cost items. This is most often noticeable with allocative items such as overhead, machinery costs, interest rates, and land returns, and for imputed items such as unpaid labor.

There are several reasons for these exclusions or unaccounted costs. They could be definitional, conceptual, or technological. The most easily handled is a definitional problem in which the affected cost item is contained under a different heading or is included as part of another item (see the subsection entitled **Terminologies, Definitions, and Concepts** earlier in this chapter). For example, in Argentinean cost estimates, machinery overhead is very low, but custom hire costs are significantly greater than U.S. estimates. In this case, U.S. estimates generally assume machinery ownership, while Argentinean estimates assume a greater amount of custom hire for machinery operations. In comparing costs, one needs to point out these differences, but no adjustments to the estimates are needed.

Exclusions can result from a conceptual difference where it is not customary to include this item in the subject country's estimates. Interest on operating capital, land charges (rent or actual ownership costs), and family labor are some cost items that are sometimes omitted from country estimates. These are usually significant cost items that need to be included if realistic intercountry comparisons are to be made.

In some instances, exclusion of an item can result from a significantly different use of technology. For example, traditional cultivation methods in low-income countries (e.g., corn in Thailand) or specific policy-cost-price structures can preclude the use of certain machinery or chemicals. In these cases, cost item exclusion might not be a problem for intercountry comparisons. Also, as in the Argentinean corn situation discussed previously, soil fertility might be provided principally as part of a rotation. A similar situation can result from double cropping where there is a residual carryover of fertility from one crop to another, or shared overhead costs during one calendar year. In these cases the exclusion of fertility costs or the over- or under specification of a cost item from the estimate for a specific crop in the rotation will misrepresent the true cost in the subject estimate. Some attempt should be made to allocate these costs equitably to the individual enterprise estimates.

There are several ways to deal with these issues in CAR estimates.

1. In some instances, secondary information sources can be used to estimate the missing cost data—e.g., commercial interest rates for interest on operating capital.

2. Missing cost information could be estimated from similar cost items in other enterprise estimates in the same country; e.g., land preparation costs might be similar for wheat and rye. Alternatively, estimates can be secured for the same crop estimate in a country where production and policy situations are similar.

3. If no information can be found to estimate the missing values, a partial cost comparison can be made by eliminating the item from all of the country estimates. Thus the

comparison can be made on a nonland cost basis, or without charging for interest on operating capital, or on a cash cost basis only.

Product and Input Definitions

Comparison of production CAR estimates among countries begins with identification of the product. Translation from one language to another is the obvious first step in comparison, and consultation with someone knowledgeable in both languages might be required. Once agreement is reached on the product name, however, there remains the issue of product definition. For example, "Grade A Milk" in Canada goes by the same name in the European Community, but the products differ in fat content and other specifications. The differences are significant in terms of production costs and market prices.

The importance of product definition depends upon the ultimate use of CAR estimates. If the objective is to resolve issues associated with international trade such as tariffs, quotas, and subsidies, accurate product definition is crucial to the analysis. If use of the estimates is confined to an investment program within a country, and if the product is intended only for domestic consumption, production definition could be less important.

Correct input definitions are also required to determine qualitative and quantitative equivalency among CAR estimates, and to adjust measurements and prices properly if they are incorrectly stated.

The issues associated with intercountry comparison of product and input definitions are sometimes equally relevant to intracountry comparisons. Regional language and cultural differences in countries such as India and Peru require the same diligence in comparison as do intercountry comparisons. For example, 46 different terms and/or measures of land area are in use in Peru (Instituto Nacional de Estadistica). The checklist shown in Table 11.1 can be used to verify that a product is defined accurately.

Alternatives

If the product definition is missing from the estimate, and if it is of consequence, the issuing agency should be contacted for clarification. If the definition is clear and the products are different, adjustments can be made by estimating the cost and revenue increases or decreases required to achieve comparability. For example, if the compared product is not cleaned or graded, the estimated cost of doing so should be added to make it comparable. Unfortunately, the specific information required to make such adjustments is often not available to the investigator. Furthermore, sometimes the activity cannot be physically performed in the country of product origin, hence no cost estimate is available. In such cases, the best the analyst can do is to make a subjective estimate.

TABLE 11.1 Checklist for Comparison of Product Definitions

Characteristic	Indicators
Grades & Standards	Variable according to the product. Examples include quality factors (below), shape, size, moisture content, impurities, weight.
Quality	Appearance, texture, flavor, nutritive value, safety.
Level of Transformation	Level 1:Cleaning, grading, drying.
	Level 2:Ginning, milling, cutting, mixing.
	Level 3:Cooking, pasteurization, canning, dehydration, weaving, extraction, assembly, freezing.
	Level 4:Chemical alteration, texturization.
Packaging	Bulk, containers, labeling.

Sources: USDA Grade Standards; Kader; Austin.

Measurement Issues

The Purpose of CAR Estimates

Estimates are generated for various reasons. Some agencies use them as would an extension worker—as a recommendation or guideline. Others use them as a maximum—such as lending limits by an agricultural bank. Some estimates are prepared to assist in setting product prices. For most analytical purposes, however, the CARs should reflect actual production practices. Given the different purposes, it therefore behooves the investigator to find out the intent of the issuing agency; different purposes can lead to different estimates.

Whose CARs are Being Estimated?

The producer is the assumed beneficiary of net returns shown in CAR estimates. There are instances, however, when some producer costs or revenues are hidden, or when the proceeds are shared. For example, if a government agency purchases the product but delays payment for several months during a period of high inflation, the producer suffers a devaluation of revenue; part of the real value of net returns therefore accrues to the government. A landowner or marketing intermediary might take a share of net returns due to "tied" production or marketing arrangements not reflected in the CAR estimates. Examples include repayment for credit advanced in cash or in kind, which can be paid via product price discounting or repayment in kind (e.g., a portion of production). If the distribution of net returns is important to the analyst, an effort should be made to ensure that the production and sales transactions reflect an anonymous market, and that hidden costs and revenues do not influence distribution of the proceeds.

"Representativeness" of Data

Cost and return estimates should represent all producers within a specified category, such as soybean growers in a particular region of Brazil. As indicated in Chapter 12: Data Sources and Statistical Issues, there are various ways of collecting CAR data. The United States and other countries use probability samples, farm record systems, and/or the economic engineering approach to generate the data required to prepare CAR estimates. Just as there are problems in comparing estimates from alternative data sources within a country, so are there problems between countries. In an ideal world, comparisons between countries would only be made where the statistical reliability of the estimates is measurable and made available. Unless a large-scale survey is used to generate CAR estimates, there is usually no statistical verification of representativeness. It has to be recognized, however, that international comparisons of CAR estimates will be made whether or not these ideal conditions apply. Where they do not, the analyst must exercise his judgment regarding the "reasonableness" of the data collection methodology. If both statistical verification and data collection methodology are unspecified, the analyst can try to obtain an explanation from those who prepared the estimate.

If a CAR estimate is judged to be unrepresentative, the analyst can attempt adjustment or redefine the population. For example, if the estimate is found to represent only the top 10% of producers in a category, the analyst could lower the productivity estimate to a level representing the mean of all producers, or subdivide the population and generate a separate estimate for each group. The reality is that the analyst of other countries' CAR estimates rarely has access to the information required to adjust for unrepresentativeness.

Prices and Quantities

The analyst sometimes cannot take reported prices and quantities at face value. For example, the reported product price could be a government-administered or support price in lieu of a market price; the reported quantity could be only that which is marketable at a premium price, while some quantity of inferior grade is used for other purposes such as livestock feed. The possibilities for misinterpretation of CAR price and quantity estimates from an unfamiliar source are endless, and once again the analyst must pursue the explanation by contacting the source.

Labor Quantity and Value

Perhaps no production input is more difficult to measure than labor. In many countries the farm family constitutes a dominant and captive labor force, the returns to which might not equal the market wage rate. There also exists the issue of labor equivalency between men, women, and children. Nevertheless, CAR estimates typically assign a market wage rate to both family and hired labor. The requirement of wage assignment sometimes leads to calculations indicating that no product is profitable enough to continue farming and ranching, yet somehow producers continue to operate their farms. As long as families are involved in production agriculture, there will be difficulty measuring how much labor is expended and what is its market price.

In some societies, hired agricultural workers receive payment in kind ranging from food to living accommodation. The preparer of CAR estimates could try to estimate the values of noncash payments, but the difficulty of doing so is usually avoided by substituting a cash market wage for a similar activity from the same region.

Labor time and cost might be accurately reported in CAR estimates, but the numbers are not always what they seem to be. In Honduras the unit of agricultural labor (work day) varies from four to eight hours depending on location (Parks et al., 1980). In Grenada, West Indies, agricultural labor contracts by task in lieu of time; thus it is difficult to know the actual time expended and the actual wage rate.

To compare CAR estimates from different countries the analyst must check the source. Again, cost adjustments can be made if the information is available, but the analyst rarely has access to such detail in another country.

Interest Rates

The nominal market rate of interest varies in part with the rate of inflation. If a high interest rate is used in the CAR estimates, the opportunity costs of capital and operating expenditures will also be high, thereby partially offsetting the effects of price inflation. Preparers of CAR estimates in many countries unfortunately do not include these opportunity costs, which results in overestimation of net revenues. If excluded, the analyst can try to adjust costs upward. The best alternative is to put all costs and expenditures on a real basis as of the end of the reporting period. This involves using nominal interest rates (including inflation) for the production period and using real revenues, costs, and interest rates for future periods in computing the costs of capital goods. Fuller discussions of interest rates are contained in Chapter 2 and also in Chapter 6 on durable machinery and equipment.

Activity Timing

For various reasons, the timing of production and marketing activities will vary within a calendar year across countries. Northern and Southern Hemisphere countries will have seasons reversed, resulting in a six-month lag (or advance). Other production cycles will be defined by monsoon (rainy) and dry seasons. This may also affect the length of the marketing season in countries that are minor actors in international markets. For example, soybean prices normally advance from harvest time (autumn in the Northern Hemisphere), rising for the interharvest period to reflect cost of storage. Southern Hemisphere harvests occur in the March-April period leaving a high international price window of four to five months until the new Northern Hemisphere crop depresses prices again. If a country takes advantage of this window, its average annual price could be somewhat higher, and storage costs somewhat less. Where these factors are present in international comparisons, they should be noted.

In some cases, in particular those involving the assessment of alternative investment decisions, international comparisons may involve multiyear crops covering different time horizons—e.g., a 10-year crop versus a 20-year crop. The procedures discussed in Chapter 10: Allocating Preproductive Costs for Multiyear Enterprises should be followed in these circumstances.

Technological Differences

Unlike distortions in monetary values and measurements, technological differences must be accepted as they are. There are numerous reasons why crop and livestock production technologies differ, the most important of which are the relative cost differences of capital and labor, and the different production and marketing systems among countries. The principal task of the analyst is to determine if the same conditions have been met in terms of product definition, time and place of delivery, and form. Differences in production technology could affect these conditions. For example, if a different production technology creates a slightly different product, a market price differential might exist.

Differences in production technology among countries are sometimes difficult to understand for the analyst who is unfamiliar with a country's conditions or culture. For example, the term "pajarero" appears in CAR estimates in some parts of Mexico and Central America. This term pertains to a person who roams fields with a slingshot or gun, shooting at birds to keep them from devouring ripe grain. This understanding, however, is not essential to a comparison of grain production CARs between Honduras and another country because it does not materially affect the product definition, form, or time and place of delivery. As long as it is a legitimate cost, correctly measured and valued, it is not an issue of concern. Conversely, comparison of salad tomato CAR estimates for Mexico and the United States might reveal that different technologies yield different products in terms of color and firmness.

Financial Accounting Versus Economic CARs

Financial accounts make use of market prices paid or received to calculate CARs from the point of view of the producer within his own country. Economic analysis expresses CARs either in terms of opportunity cost or in values determined by the willingness to pay. The price that is substituted for the market price is called a **shadow price**. There are three categories of adjustments to financial statements to reflect economic values: (1) adjustment for direct transfer payments, (2) adjustment for price distortions in traded items, and (3) adjustment for price distortions in nontraded items (Gittinger). (Note that traded items pertains only to imports and exports, not trading within the country.)

In nearly all CAR comparisons related to trade, the analyst seeks financial values, not economic values. Financial values are the ones to which farmers respond, and that enter the world marketplace. Economic values are typically used only by governments or international agencies contemplating investment decisions. Guidelines for conversion of CAR estimates from financial to economic values can be found in numerous publications, including works by Gittinger and by Brown.

INTERNATIONAL COMPARISON OF PRODUCTION CARs: A CASE STUDY OF FIELD CORN IN CALIFORNIA AND HONDURAS

As discussed above, comparisons of production CAR estimates from different and dissimilar countries require both skill and imagination. Without firsthand knowledge of agricultural production in both countries, the analyst might face a difficult task in trying to understand obscure agricultural terms, convert unfamiliar units of measurement, or imagine what is missing. In this case, however, the analyst has experience in both

California and Honduras. The comparison made in this analysis is between typical Honduran practice and a special case in California—low input corn production. The California data is experimental in nature and does not represent typical farm practice. The Honduran system used is representative of the area and thereby capital deficient and low input by California standards. Structuring the comparison this way examines whether or not a low-input system by California standards is low input from an international perspective.

Objective of the Comparison

The objective of the comparison is to convert this Honduras CAR estimate to conform to a particular set of California CAR standards such that both are identical in time, form, and space. In practice, it will rarely be possible or necessary to achieve perfect comparability, and this comparison is no exception. Conversion of the Honduras CAR estimate to the California standard is an arbitrary choice; the California CAR estimate could just as well be converted to the Honduras standard. Neither the Honduras estimate nor the California estimate conform exactly to the guidelines of this report. The object of the exercise is to make the two comparable with one another, not to adjust them both to fit the guidelines of this report strictly.

The CAR Estimates

The California CAR estimate for San Joaquin Valley field corn (low input system) was prepared by the University of California Cooperative Extension Service (University of California). It is a 13-page document that clearly lists assumptions and conditions, and is calculated with the aid of a computer. For brevity, only the summary table is presented here (Table 11.2). The Honduras CAR estimate was prepared originally in 1979 (Parks et al., 1980), translated from Spanish, with monetary values updated to 1992 (Table 11.3A, B, C).

Comparison of California and Honduras CAR Estimates

A recommended first step in the comparison is to list the principal differences between the CAR estimates (Table 11.4). This can be a challenge if the analyst lacks a full and complete understanding of both estimates. The Honduran production is designated "high yield" because it represents the best technology used in the San Pedro Sula Valley, although by U.S. standards the technology is rudimentary. The absence of any entries pertaining to irrigation in the CAR estimate is a clue that this crop is not irrigated. The investment in infrastructure and equipment is low, with ownership costs (excluding land) not exceeding 10% of operating costs.

The Spanish version of the CAR estimate lists a labor entry for "dobla," or “bending” the corn stalk, which is said to date from the time of the Mayans. This practice consists of stripping the stalk of leaves and bending it so that the ears of corn hang upside down. In this position the husk sheds water and the sun dries the corn on the cob. Bending can therefore be considered as the cost of drying.

Two apparent omissions from the Honduras estimate are the cost of land and the cost of transport to a grain elevator or market. The cost of land is an important omission, but the cost of transport to market is reflected in the farmgate price; marketing intermediaries typically purchase grain at the farm and transport it to market or a storage location. The fixed costs of structures are excluded because they are usually minimal.

Adjustments

The sequence of adjustments is arbitrary, but in this case physical units are adjusted before currency. An example of input quantity and cost conversion follows.

1. Adjust Honduras labor time for the difference in land base:

$$\frac{2.8 \text{ days planting labor in May}}{1.73 \text{ acres per manzana}} = 1.62 \text{ days per acre}$$

2. Adjust Honduras wage rate (Lempiras/Manzana) to U.S. dollars:

$$\frac{L.\ 10.00 / \text{day}}{5.4 \text{ Lempiras } / U.S.\$} = \$1.85 / \text{day}.$$

Once the CAR estimate is adjusted for land and currency units, adjustments could be made for missing items, as well as differences in assumptions and conditions. The adjusted Honduras CAR estimate (without adjustments for assumptions) appears in Table 11.5, with explanations as follows.

Land Cost

A person was contacted in Honduras to obtain an estimate of land rent for unirrigated land in the San Pedro Sula Valley, suitable for corn production. The response was L. 1,000 to L. 1,500 per manzana per year, depending on the site, the size of the leased parcel, and the type of lease agreement. Assuming potential for two crops annually, the rental cost of land per crop therefore varies from about $50 to $80 per acre. The choice of the midpoint of $65 per acre is arbitrary.

Interest Rate

Both the California and Honduras estimates use the nominal approach to estimating CARs and use a nominal interest rate for all calculations. Recalculation of ownership costs is unnecessary because the rate used by the University of California Cooperative Extension (12.0%) is identical to that used in the Honduras estimate. In the event of a difference, however, costs that are affected by the interest rate should be recalculated for the Honduras estimate using the rate of interest employed in the California estimate if it is assumed that the opportunity costs of funds and inflation are the same in the two areas. If the real rate of interest and the rate of inflation are different, then it would be appropriate to recompute the California and the Honduras estimates using the real rate of interest in the respective areas for computing the costs of opportunity interest (and estimating salvage values, future revenues, etc.) for periods outside the current one. This could be a tedious and perhaps impossible task if there is too much or too little detail provided in the CAR estimate. Given the small proportion of interest-affected costs in Honduran agriculture, recalculation for small differences in the interest rate would appear to be unnecessary given the potential for greater error in other variables.

Time of CAR Estimate

The California CAR estimate was completed in 1992—the same year for which the Honduras estimate was updated—hence no time adjustment is necessary. However, there are three possible scenarios the analyst might face.

1. If the California estimate were current and the Honduras estimate were not, the Honduras estimate could be updated by simply applying the current currency exchange rate, which takes into account both currency inflation and devaluation against the dollar. This simplified approach assumes uniformity in the rate of price inflation for all inputs and the product price. The alternative of seeking updated prices for each input would likely be too difficult unless the analyst had a helper in the other country.

2. If the Honduras estimate were current and the California estimate were not, the California estimate could be updated either by obtaining current input and product prices, or by adjusting prices globally according to the rate of inflation. One source of useful information for this adjustment is the *Agricultural Outlook* publication from USDA/ERS (USDA, 1992), which indicates price changes by input category.

3. If neither CAR estimate were current, the same techniques described above could be used to adjust costs to a common point in time.

Omissions and Unresolved Problems

There are some unresolved problem areas associated with this comparison of CAR estimates in California and Honduras.

Product Definition

The corn products in California and Honduras are not identical. Although production costs are probably not greatly affected by the varietal difference, market price definitely could be. Honduras does not typically produce sweet corn for human consumption and field corn for animal consumption; corn is produced for making tortillas, and some is diverted to animal feed.

Currency Conversion

The currency conversion rate is a "spot rate" as of June, 1992. However, the annual rate of inflation in Honduras was between 20% and 30% in 1992, with frequent devaluations against the dollar. Instability of the exchange rate over time could result in distortions of value.

Export Prices

If the analyst were interested in trade competitiveness, the costs of transportation to, and storage at, a port could be added to the CAR estimate.

Comparison of Results

There are numerous technical comparisons that might interest the analyst. The focus in this section is on the aggregate CARs to corn production.

TABLE 11.6 Summary Cost Comparison between California and Honduras Corn Production

Measure	California	Honduras
Operating Cost/Acre	$322.63	$126.20
Operating Cost/Ton	54.50	70.44
Total Cost/Acre	458.13	216.65
Total Cost/Ton	77.39	120.90
Net Revenue/Acre	104.27	82.01
Net Revenue/Ton	17.61	45.77

The estimated cost of producing corn in Honduras is less than one-half that of the low-input California system on a per acre basis. Since the California system produces 3.3 times more corn per acre than Honduras, however, the cost per ton produced is lower in California. Even with an estimated corn price in Honduras that is 76% higher than the California price, California production is more profitable on a per acre basis. Honduras corn is more profitable on a per ton basis.

Due to the volatility of product prices—especially in Honduras—the net revenue estimates are suspect. The highest farmgate price of corn in Honduras is typically triple the low price within the course of a year. This phenomenon emphasizes the necessity of focusing on what is important; it makes little sense to tinker with a small difference in the interest rate used to calculate ownership costs when enormous fluctuations in corn price and rapid currency devaluation dominate the outcome.

TABLE 11.2 Costs and Returns per Acre to Produce Field Corn

Low Input System: Sacramento Valley, 1991 - 92
Labor Rate: $8.04/hr. machine labor — Interest Rate: 12.00%
$5.70/hr. nonmachine labor

	Quantity/Acre	Unit	Price or Cost/Unit	Value or Cost/Acre
GROSS RETURNS				
Grain	5.92	ton	95.00	562.40
TOTAL GROSS RETURNS FOR CORN				562.40
OPERATING COSTS				
Water:				
Water, district	36.00	acin	1.93	69.48
Seed:				
Lana vetch seed	50.00	lb	0.75	37.50
Corn seed	30.00	thou	1.05	31.50
Fertilizer:				
6-20-20	100.00	lb	0.15	15.00
34-0-0	205.00	lb	0.13	26.65
Labor (machine)	4.31	hrs	8.04	38.93
Labor (non-machine)	1.98	hrs	5.70	11.29
Fuel - Gas	0.29	gal	0.98	0.28
Fuel - Diesel	39.37	gal	0.71	27.96
Lube				4.23
Machinery repair				38.74
Interest on operating capital @ 12%				21.08
TOTAL OPERATING COSTS/ACRE				322.63
TOTAL OPERATING COSTS/TON				54.50
NET RETURNS ABOVE OPERATING COSTS				239.77
CASH OVERHEAD COSTS				
Land Rent				60.82
Office Expense				12.16
Property Taxes				3.07
Property Insurance				1.54
Investment Repairs				0.08
TOTAL CASH OVERHEAD COSTS/ACRE				77.66
TOTAL CASH COSTS/ACRE				400.29
TOTAL CASH COSTS/TON				67.62
NONCASH OVERHEAD COSTS (DEPRECIATION & INTEREST)				
Buildings				2.74
Shop Tools				0.25
ATV, 4wd				0.40
Equipment				54.45
TOTAL NONCASH OVERHEAD COSTS/ACRE				57.84
TOTAL COSTS/ACRE				458.13
TOTAL COSTS/TON				77.39

NET RETURNS ABOVE TOTAL COSTS	104.27

Source: University of California.

TABLE 11.3A Costs and Returns of Corn Production in the San Pedro Sula Valley, Honduras, 1992

Crop: Corn, high yield (62 cwt/manzana)
Region: San Pedro Sula and Yojoa
Author: Manuel de J. Sanchez, Banco Nacional de Desarrallo Agricola

Month	Labor (days)	Total Units	Cost per Unit (L.)	Total Cost (L.)
May	Plant	2.8	10.00	28.00
May	Apply fertilizer	2.0	10.00	20.00
May	Apply herbicide	4.7	10.00	47.00
June	Apply urea	2.8	10.00	28.00
July	Weeding/cultivation	1.5	10.00	15.00
August	Strip and bend stalks	10.5	10.00	105.00
September	Harvest and field haul	14.5	10.00	145.00
Other Contracted Services				
April	Annual land clearing	per Mz.	110.00	110.00
May	Plow and disc 2X	4.0 days	15.00	60.00
May	Plant (hired bullocks)	1.3 days	55.00	71.50
June	Furrow (hired bullocks)	1.3 days	55.00	71.50
October	Remove grain (machine)	per cwt.	2.30	142.60
Materials				
May	Improved seed	30.0 lb	1.10	33.00
May	Fertilizer	1.1 cwt	68.45	75.30
May	Herbicide	2.0 kg	48.60	97.20
June	Urea	1.5 cwt	69.00	103.50
June	Insecticide	16.0 lb	1.65	26.40
Sub-total (Operating Costs)				1,179.00
Other Costs				
Interest on invested capital (12%)				64.34
Interest on operating capital (12%)				29.48
Depreciation				111.48
Maintenance				32.40
Total Cost of Production				1,416.70
Total revenue @ L.45/cwt				2,790.00
Net revenue per manzana				1,373.30

Source: Parks et al., 1980.

TABLE 11.3B Ownership Costs

Equipment	Number	Initial Cost	Scrap Value	Useful Life	Manzanas per year
Backpack sprayer	1.00	225.00	40.00	4.00	20.00
Bags (35)	1.00	43.75	.00	2.00	1.00
Fence	1.00	1,050.00	200.00	5.00	10.00

Source: Parks et al., 1980.

TABLE 11.3C Allocated Ownership Costs

	Totals			Per Manzana		
Equipment	Interest†	Depreciation‡	Maintenance	Interest	Depreciation	Maintenance
Sprayer	15.9	46.25	40.00	.80	2.31	2.00
Bags	2.62	21.88	.00	2.62	21.88	.00
Fence	.75	170.00	100.00	7.50	17.00	10.00
Totals per manzana				10.92	41.19	12.00

Source: Parks, et al., 1980.

† Interest computed as $OC = \left(\frac{PP + SV}{2}\right)(i) = \left(\frac{225 + 40}{2}\right)(0.12) = 15.9$ for the sprayer

‡ Depreciation computed as $D = \left(\frac{PP - SV}{n}\right)$

TABLE 11.4 Comparison of Production Cost and Return Estimates

Field Corn: California and Honduras		
Item	California	Honduras
Production definition	Field corn	Not available
Product use	Animal feed	Multipurpose, but primarily for human consumption
Date of estimate	1990	1992
Harvest month	October	October
Container	Bulk	Bags of 100 lbs.
Price location	Delivered to grain elevator	Farmgate
Measurements		
Product	Ton (2,000 lbs.)	Hundredweight (cwt)
Land	Acre	Manzana (1.73 acres)
Currency	US $	Lempira (L. 5.4 per $US)
Labor	Hour	Day
Interest rate	12.0%	12.0%
Farm/field size	300 acres corn on 1,200 acre farm	Not specified
Water source	Irrigated	Rainfed
Principal omissions		Land cost

TABLE 11.5 Adjusted Costs and Returns of Corn Production in the San Pedro Sula Valley, Honduras, 1992

		Yield: 1.79 tons/acre		
Month	Labor (days)	Total Units	Cost per Unit ($)	Total Cost ($)
May	Plant	1.62	1.85	3.00
May	Apply fertilizer	1.16	1.85	2.14
May	Apply herbicide	2.72	1.85	5.03
June	Apply urea	1.62	1.85	3.00
July	Weeding/cultivation	0.87	1.85	1.61
August	Strip and bend stalks	6.07	1.85	11.24
September	Harvest and field haul	8.38	1.85	15.52
Other Contracted Services				
April	Annual land clearing	1.00 acre	11.77	11.77
May	Plow and disc 2X	2.31 days	2.78	6.42
May	Plant (hired bullocks)	0.75 days	10.19	7.65
June	Furrow (hired bullocks)	0.75 days	10.19	7.65
October	Remove grain (machine)	1.79 tons	8.52	15.26
Materials				
May	Improved seed	17.34 lb.	0.20	3.53
May	Fertilizer	0.64 cwt	12.68	8.06
May	Herbicide	1.16 kg	9.00	10.40
June	Urea	0.87 cwt	12.78	11.08
June	Insecticide	9.25 lb.	0.31	2.83
Subtotal operating cost/acre				126.20
Subtotal operating cost/ton				70.44
Other Costs				
Interest on invested capital (12%)				6.89
Interest on operating capital (12%)				3.16
Depreciation				11.93
Maintenance				3.47
Land rental				65.00
Total cost of production per acre				216.65
Total cost of production per ton				120.90
Total revenue/acre @ $166.67/ton				298.66
Net revenue/acre				82.01
Net revenue/ton				45.77

CHAPTER 12

DATA SOURCES AND STATISTICAL ISSUES

INTRODUCTION

The foundation of cost and return (CAR) estimation is the data on which those estimates are based. Therefore a critical step toward establishing uniformity in the methodology used in generating CAR estimates is to examine the sources of these data and to investigate conditions under which each may provide a suitable basis for analysis. The purpose of this chapter is to encourage the analyst to look closely at the data, their strengths and weaknesses, and their suitability in the specific context in which the analyst is producing CAR estimates.

This chapter discusses and compares the most common sources of data for CAR estimates. Data for CAR studies can be obtained in a variety of ways including the use of large-scale probability surveys designed to collect primary data about cost of production, the use of data from farm records systems, the use of information obtained from a single farming operation, and the use of agricultural engineering equations based on field data. Each has its place in providing data for CAR estimation. The chapter also examines a variety of statistical issues that are relevant to obtaining and using data in analysis and estimation.

House, in her remarks at a conference on CAR estimation, stated that quality data must provide estimates that are "accurate, defensible, affordable, and ... target the desired population" (House: 81). There are many factors in the data collection process that are important for assuring those qualities, but perhaps the most important is statistical inference. Statistical inference determines whether, and to what extent, results from the analysis and estimation can be generalized to a broader set of farming operations. Statistical inference is largely determined by two activities: precisely defining the group (or target population) the analyst wants to investigate, project for, or draw conclusions about; and selecting representative data from that population for the analysis.

Defining the Target Population

In the context of this publication, the target population for a data collection activity is the group about which the analyst wishes to make CAR estimates. Commonly the target population will be the subset of farms engaged in a very specific farming enterprise within a localized geographic area. Examples of target populations in this context are all farms engaged in dairy production in the upper Midwest, or farms engaged in cotton/almond production in the San Joaquin Valley. For certain purposes the target population may need to be defined even more precisely. Extension economists may want to develop CAR estimates that are representative of progressive, well-managed farms (rather than all farms) engaged in the selected enterprise because those estimates may be more useful in guiding potential producers. On the other hand, the United States Department of Agriculture (USDA) and others producing historical estimates will generally want to include a broader geographic area and to target all farms engaged in the enterprise regardless of whether they are progressive or not.

Chapter 12. Data Sources and Statistical Issues

Many different groups can be targeted legitimately for CAR estimation depending on the analytical needs and budget of the particular endeavor. A problem arises, however, when an analyst targets one population for CAR estimation but chooses a data collection method that actually focuses on some other group.

Selecting Representative Data

The second step in the process of obtaining data is to select a representative sample of data from the target population in such a way that valid inferences can be maintained. Two general types of samples are possible: a statistical sample, or a judgment sample.

A statistical (or probability) sample is one in which each farm in the targeted population has a positive and knowable chance of being included. The probabilities of inclusion in the sample are used to produce sample weights, which in turn convert the estimates produced from the data into estimates representative of the entire target population. Statistical theory then helps the analyst describe certain measures of the accuracy of these estimates. Because it gives a chance of selection to every farm in the targeted population, and because it can provide measures of accuracy, a statistical sample is considered to be superior to a judgment sample. If one can obtain data for CAR estimation from a statistical sample, that may be the best procedure. However, statistical sampling procedures can be very expensive, they don't produce accurate results for very small sample sizes, and they are subject to a variety of other types of collection errors. Thus, there are many situations in CAR estimation where carefully selected judgment samples are appropriate vehicles for obtaining data.

A judgment sample is selected from the population through some method other than statistical sampling, usually the subjective decision of one or more individuals. This means that at least some units in the population have no chance of selection and/or it is not possible to determine what the selection probabilities (and thus the sample weights) are. Williams indicates that judgment samples are problematic because "the accuracy of judgement samples cannot usually be determined. They are not necessarily inaccurate, but if they are accurate the accuracy is usually unknown and depends upon the expertise of the specific individual [selecting the sample]" (Williams: 47). In general there can be little empirical assessment of the accuracy of CAR estimates made from data collected from a judgment sample. The analyst should be aware of this serious limitation before choosing this approach to data collection.

DATA SOURCES

This section is divided into two parts. The first part presents a brief discussion of three alternatives for generating data that can be used to produce CAR estimates and/or to analyze various other aspects of the structure of production in farm firms. The second part consists of a brief review of several studies that have compared the implications of using different data sources from the same general population to examine CARs and other farm level characteristics.

Alternatives for Generating Data

Although there are numerous alternatives for generating data for CAR estimates, three of the most commonly used methods will be discussed here. The three alternatives for generating data required in the preparation of CAR estimates for agricultural commodities are (a) probability surveys, (b) farm record systems, and (c) the economic engineering approach.

Probability Surveys

The major source of data collected using probability surveys is the federal government. Three sources of farm survey data identified by J. D. Johnson are (1) the Census of Agriculture, (2) special follow-on surveys to the Census of Agriculture (e.g., farm finance or irrigation surveys), and (3) USDA farm economic surveys, particularly the Agricultural Resource Management Study (ARMS). This comprehensive set of surveys was previously conducted under the name Farm Costs and Returns Survey (FCRS). A second source of data generated from probability surveys is work that takes place in a few states under the auspices of land grant universities.

For the purposes of the present discussion, we want to focus on two specific probability surveys, one at the federal level and the other at the state level. The federal-level survey is the Agricultural Resource Management Study data collection process, a cooperative project by USDA's Economic Research Service and National Agricultural Statistics Service. The state-level discussion centers on procedures used by the Louisiana and Mississippi Agricultural Experiment Stations.

The ARMS data are collected through a nationwide survey of approximately 26,000 farm and ranch operators. A main objective of the survey is to collect data to develop weighted average costs of production (COP) estimates for specific farm commodities. Each observation is intended to be representative of a number of similar farms. In addition, the survey generates data that are useful in examining a variety of farm-level issues such as efficiency, income and wealth levels, capital formation, and financial structure (J. D. Johnson). The commodities included in the survey depend on legislative mandate and on USDA needs. Given the high costs associated with conducting the surveys, data are collected for individual commodities every four to five years on a rotating basis (Morehart, Johnson, and Shapouri).[1]

Activities in Louisiana and Mississippi illustrate the generation of data from probability surveys at the state level. Although they work independently, the Experiment Stations in these two states follow very similar procedures to produce data for CAR estimation. Both stations cooperate with the National Agricultural Statistics Service (NASS) to conduct probability surveys of producers of major enterprises within various regions of the states. The surveys are conducted for each enterprise on a rotating basis every three years. The data collected from the surveys of producers are used to identify farming practices and the type and quantity of materials typically used by the farms in the various regions. The producer surveys are supplemented by

[1] For details concerning the ARMS data see J. D. Johnson, and Morehart, Johnson, and Shapouri.

state-wide surveys of suppliers to collect input price information and by additional information provided by extension personnel.[2]

When compared to other major sources of data for CAR estimation, the advantages of probability surveys rest in two important areas. First, only a probability survey can provide statistical inference to a broad array of potential target populations within the farm sector. Second, one can statistically describe the accuracy of CAR estimates that were based on probability data. With other sources, the accuracy is hard to measure and generally unknown. These points are discussed by House. However, data collection costs pose a major disadvantage to using probability surveys to obtain data. Another disadvantage is that few if any of these probability-based data sets are collected longitudinally. Data are typically collected once for a cross section with no follow-on in subsequent years. Hence, these data sets lack the richness over time often available through methods discussed in the following sections. Furthermore, problems outlined in the section entitled "Reliability Issues With Data" are applicable to data collected through probability surveys. Finally, probability surveys are likely to have confidentiality restrictions imposed upon release of their data, making these data sets difficult to share with the research community.

Farm Record Systems

Stovall and Hoover indicate that farm record keeping systems emerged during the 1940s in several midwestern states and gradually spread to other areas primarily in response to the increasing complexity of income tax rules. The data for these systems are provided by farmers on a voluntary basis and are used to prepare farm business analyses which in turn are used by farmers for management decisions. In some cases, the business record associations prepare the farmers' tax returns.

The record systems are usually sponsored by farm management associations, departments of agricultural economics, Cooperative Extension, vocational-technical schools, and/or Farm Credit Banks. According to Casler, at least two dozen states currently have some type of farm record system. Traditionally, the main use of the data generated through farm record systems has been for extension and education programs. More recently, however, several researchers have utilized these data to examine a wide range of issues in production economics and agricultural policy.

Two types of data result from farm record systems: (1) original individual farm records, and (2) aggregate business summaries that are typically published annually by the various systems. These summaries often subdivide the farms by size class, location, and/or some other salient feature and provide detailed physical and economic data for each group.

A major advantage of the data stemming from farm record systems is their high level of accuracy because of the scrutiny usually given to the information by field supervisors (Batte and Sonka). Another

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[2] Empirical studies using data generated from probability samples can be divided into econometric and noneconometric. Examples of econometric studies are the papers by Weaver and Lass, and Huy et al. Examples of noneconometric studies are the papers by Hazilla and Kopp, Cooke and Sundquist, and USDA/ERS 1990a, 1990b.

important advantage is that in many cases individual records are available for the same farmers over a number of years, which makes it possible to apply panel data analysis techniques. In addition, the annual summaries are a unique source of high-quality, disaggregated time series data, which researchers have just begun to exploit. Unfortunately, these data also present several problems. One problem is the difficulty in building a data set covering several states. Even if access to data is secured from several states, the procedures used across states are often incompatible (Casler). Another important shortcoming of business records is that the farms included in these data sets do not proportionately represent the entire farm population. Willimack estimated that only 11% of farming operations across the country currently use such a service. Furthermore the percentage differs by type and size of farm. Thus, inferences to sizable portions of the farm sector are problematic, and no conclusive statements can be made concerning those populations. The extent to which data from business records differ from that of random samples for a given population has received some attention in the literature and is a point which will be discussed later.[3]

The Economic Engineering Approach

The economic engineering approach has been widely used to generate data required to produce CAR estimates, as well as estimates of other features of farm operations, particularly economies of size. This approach combines input-output information gathered from engineering, biological, and other relevant technical disciplines with information collected from the field (e.g., from farmers and extension agents) and with accounting data to estimate CARs or other measures of performance. Developing CAR data via economic engineering often requires that the researcher define a typical farm situation.

The procedures used to generate data, define variables, and characterize the typical or representative farm can range from very formal to very casual. The more formal procedures make use of the Delphi method (Pill). The methodology used in the more casual cases varies greatly from case to case (Klonsky 1992). Casual procedures tend to be the most frequently used in the field.

In order to illustrate a formal procedure to generate data for representative farm analyses, consider the approach used by researchers from the Agricultural & Food Policy Center (AFPC) located in the Department of Agricultural Economics at Texas A&M University. For several years, researchers at the AFPC have used whole-farm simulation models to examine the effects of farm programs on representative agricultural firms for various regions of the United States. The information required to construct the farm models is collected from producer panels for a particular type of operation in a given region. The producer panels provide information on the size of the typical operation, tenure arrangements, enterprises, costs of production for the various enterprises, crop yields (expected and historical), and machinery complements (Knutson et al. 1992). After the information is collected and processed it is reviewed by the panel members. The data are then incorporated into the farm-level policy model to produce pro forma financial statements for the panel farm. These statements are once again reviewed, adjustments are made, and this process is repeated until the panelists are

[3]Empirical studies using individual records have been published by Batte and Sonka; Hornbaker, Dixon and Sonka; and Bravo-Ureta and Rieger, among others. Examples of studies relying on annual summaries of business records are the papers by Adelaja; Foster and Rausser; Quiroga and Bravo-Ureta; and Cocchi.

satisfied that the financial projections are reasonable. Additional data are collected for each region with the assistance of appropriate land grant personnel. Information collected in this fashion includes interest rates, Commodity Credit Corporation (CCC) loan rates, prices received for outputs and paid for inputs, and income tax information. Finally, macroeconomic data, policy assumptions, and prices for policy analyses are obtained from the Food and Agricultural Policy Research Institute (FAPRI) located at the University of Missouri-Columbia and Iowa State University (Knutson et al. 1992).

The economic engineering approach is particularly useful in examining a priori the impact of possible changes in a wide range of variables such as technology, government programs, yields, and prices. This type of data, however, does not provide information on the actual farm situation. It simply illustrates what the situation would be if the assumptions incorporated into the analysis were to materialize.[4]

Comparisons of Estimates from Alternative Data Sources

The first attempt to compare formally the characteristics of farmers participating in farm record systems with those of farmers selected in random samples was undertaken by Hopkins in a study published in 1939. Hopkins compared record keeping farms with farms from a random sample and found that the managerial capacity of the former group was "definitely superior" to that of the latter. He concluded that "operating on land of approximately equal value and directing equal amounts of labor, but utilizing more short-lived capital, the record-farmers have obtained a significantly greater output and have earned higher net incomes" (Hopkins: 276).

In another early study, Mueller compared data collected by the Farm Bureau Farm Management Services for 210 cooperators from six counties in western Illinois with 193 farmers from a random sample of the same six counties. Mueller found that the record keeping farms, compared to their survey counterparts, were larger in size, had a higher investment per acre, were located on higher-quality soils, and had higher output per acre for the major grains. Land use patterns, however, were very similar in the two groups. Nevertheless, Mueller found no evidence of differences in the managerial ability of the two groups of farms. This author concluded "that differences between record keeping farms and a representative sample of all farms are essentially differences in the quantity of basic resources, particularly land and capital, utilized by the farm operators" (Mueller: 292).

Olson and Tvedt contrasted annual farm averages from the Southwestern Minnesota Farm Business Management Association (FBMA) with U.S. Agricultural Census averages for 1982. The authors' specific objective was to examine the proposition that producers belonging to farm management associations are better managers and have larger operations than the population of farmers as a whole. The authors found that the average farm belonging to the association was larger and had higher crop yields than the average census operation. In addition, the authors found that association farms had higher total investment and production expenses, which is consistent with their larger size. On a per acre basis, however, investment and production

[4] For a comprehensive, although dated, review of economic engineering studies see Madden. A more recent review was published by H. R. Jensen.

expenses were lower for association farms, which might be a reflection of higher efficiency and/or better land quality.

In a later study, Andersson and Olson examined 1987 Southeastern and Southwestern Minnesota FBMA and FCRS farm record data. They were able to use individual farm observations and thus provide a more accurate comparison to FCRS estimates than the previous Minnesota study. The specific objectives of Andersson and Olson were to examine statistically any differences in farm characteristics between the two data sets, and to ascertain the farm size classes for which FBMA farms are statistically representative of those in the FCRS system. These objectives were pursued through descriptive and statistical comparisons of several variables reflecting a variety of farm characteristics.

Andersson and Olson found that the FBMA farms are not representative of the population in the study areas. They found major differences in overall farm size, number of tillable acres, rented land, and livestock production (particularly hogs). The differences in these variables led to marked divergences in farm income between the two farm groups, although solvency conditions were very similar.

Analysis focusing on farms with sales exceeding $60,000 still showed that FBMA operations had "a higher level of livestock production and a slightly larger tillable acreage mainly due to renting additional land. Economic performance measured by net farm income and returns to total assets and family labor was significantly...better for FBMA farms. So even though differences in...solvency positions were insignificant, the economic performance measured of the FBMA farms appears to be better than FCRS farms even in larger sizes" (Andersson and Olson: 310). Based on these results, the authors concluded that the FBMA data is not representative of all farms nor of all commercial farms.

Libbin and Torell set out to compare CAR estimates developed by researchers at New Mexico State University (NMSU) with USDA's CAR estimates for New Mexico farms and ranches prepared with FCRS data. The authors also compared estimates from crop CAR estimates developed in Illinois, Kentucky, and Missouri, and from livestock CAR estimates completed in Colorado and Washington, with figures published by the USDA. These authors found substantial differences in both crop and livestock CAR estimates for New Mexico. "Crop budget comparisons for selected states other than New Mexico yielded similar disparities in budget results. Livestock budgets from the two budget sources were similar" (Libbin and Torell: 308).

Koenigstein and Lins contrasted information obtained from farmers participating in the Illinois Farm Business Farm Management (FBFM) Association with FCRS farms for the year 1986. The Illinois FBFM Association was started over 40 years ago and has more than 7,000 farms, making it one of the oldest and largest associations of this type in the country. The authors used descriptive statistics to summarize individual farm records and focused primarily on financial variables.

The Illinois study found that about one-half of the FCRS farms were small, part-time operations, while the FBFM farms were larger and full-time. According to the authors, these size differences make direct comparisons across the two groups of farms difficult; however, farms that are in a similar size class had many characteristics in common. Koenigstein and Lins found that, because of omissions of several balance sheet items, the USDA estimated only 87% of the true net worth of the Illinois operations. Similar omissions of income statement items led the USDA to measure only 81% of the true net farm income.

Gustafson et al. performed statistical comparisons of financial characteristics for 1986 farm-level data obtained from the North Dakota Farm Business Management Education (FBME) program and from the USDA's FCRS. The former data source is based on 496 farms while the latter consists of 307 observations representing a total of 24,472 North Dakota farms. This study showed that the farms participating in the record keeping program had considerably more land, hired labor, production expenses, gross income, assets, and liabilities than their FCRS counterparts. In addition, the results revealed that "equity levels on record keeping farms are higher but profitability and returns to that equity are substantially lower" (Gustason et al.: 172).

The final study reviewed here is a detailed analysis of the costs of producing rice in Texas published by Rister et al. The Texas study used the AFPC farmer panel data approach discussed previously to produce CAR estimates for rice for four representative farming situations in 1989. A comparison of the per cwt cost estimates made by Rister and his colleagues with figures developed by ERS shows that in the former case the range is from $11.68 to $14.35, while for the latter the range is from $7.00 to $8.00. Rister et al. conclude their study by suggesting reasons contributing to this divergence in cost estimates. Among the most important was Texas rice producers' seeming inability to respond fully to the questions posed by the ERS survey (both because of question misunderstandings and due to producers' lack of time as a result of the questionnaire being administered during peak planting time in March and April), thereby underestimating expenses. Another difference was ERS's use of imputed returns to estimate several costs items that have traditionally had high government payment receipts. If these receipts are not included in the imputed returns, the costs associated with these assets are underestimated to the extent that these receipts have been capitalized into asset values. Some difference arose because ERS indexed variable costs between survey years but used actual yields for each year so that the cost of the higher-yielding semidwarf varieties released and adopted between survey years was not fully represented. Another difference related to the allocation of farm overhead expenses to planted rice acres versus all farm acres. As discussed in Chapter 9, this is an area where there is little hard data and allocations are often arbitrary. Another difference is that Rister et al. included expenses for drying, storage, marketing, and checkoff expenses that are required to transfer the crop to the first off-farm handler whereas ERS considered direct production costs only. The differences here are a good example of the difficulty in preparing costs of production estimates, and the importance of documenting assumptions so that users can adjust the estimates to fit a particular need or comparison.

RELIABILITY ISSUES WITH DATA

When one selects a sample (either a statistical sample or a judgment sample) from a population and uses information from the sample to represent that population, it is important that the representation be accurate. However, for reliability, it is equally important to know how accurate or inaccurate that representation is likely to be. Good data will be unused if the analyst does not consider them creditable. The situation is even more serious when inaccurate representations from data are perceived as correct and used as such. Without knowing the "truth," accuracy is difficult to measure. However, certain measurements and controls are possible, and this section will discuss some of these in more detail. Errors that reduce accuracy are usually categorized into two groups: sample variability and bias. To be accurate, data must allow estimation with low sampling variability and small biases.

Sampling Variability

Precision, one component of accuracy, measures how closely the results from a single sample are likely to match the results of a census conducted using similar procedures. (It does not tell whether those procedures are good or not!) An estimate is said to be "precise" when its sampling variability is small. With probability sampling, two positive results are possible. First, one can obtain objective and accurate measures of precision from the sample itself. Second, one can improve precision by simply increasing the sample size. When judgment sampling is used, one must look for subjective methods of measuring and increasing precision.

In probability sampling the standard error of an estimate is the basic measure of precision. The smaller the standard error, the higher the precision. A normalized form of the standard error, called the coefficient of variation (CV), is commonly used by analysts. The CV, given in percent, is the standard error of an estimate divided by the estimate itself. Confidence intervals can be computed using either the standard error or the CV, depending on whether one wants the interval expressed as an actual width or in relative percentage terms. A 95% confidence interval defines an interval around the estimate such that if the sampling procedures were repeated 100 times, the true (census) value would be within the interval for approximately 95 of the 100 repetitions. A 95% confidence interval has the width of four standard errors (or four CVs) and is centered around the estimate. The more "confidence" you demand in the interval, the larger that interval will be; for example, a 95% confidence interval is wider than a 90% confidence interval. If one were collecting data on the cost per hour for hired labor on farms in Illinois, for example, and decided to survey 500 farms using an equally weighted probability sample, the mean of this data divided by its standard deviation would be a measure of sampling variability. If this CV turned out to be 5, one would be concerned about using these estimates as representative of the cost of labor for all farms.

Bias and Its Sources

Confidence intervals can tell a lot about the accuracy of data when the data collection process is free of other types of errors. However, when things go wrong in the data collection process, one ends up measuring something different than what was intended. For example, an analyst may want to have an estimate of the total corn stocks held by an operation. Depending on how the question is asked, the farmer may only report those stocks physically on his property. The data collector has measured something different than what was intended. The bias is the difference between the value that was measured and the value one intended to measure.

Errors that can lead to such biases are referred to as nonsampling errors and they are universally hard to detect, measure, and control. This section will discuss three general types of nonsampling errors: response errors, nonresponse errors, and coverage problems. The focus will be on examples of such errors that are likely to occur in collecting CAR data, with discussions on techniques for avoiding or minimizing these errors.

Response Bias

Response error occurs when a respondent attempts to provide accurate information but fails to do so. The data collector is more often to blame than the respondent in these situations. Ambiguous and poorly worded questions are major causes of response error. Another common cause is asking the respondent to recall information from an earlier time period. Both situations are discussed here.

Question Design. Sudman and Bradburn give a simple principle in designing questions so that they can be answered accurately: use words that everyone will understand and that have only the meaning that is intended. Cost of production concepts are so complex that just getting agreement and consistency between analysts is difficult. It is small wonder that farm operators may have trouble understanding what is being asked. Garcia and Sonka point to how farm record systems obtain accurate information by following the principle extolled by Sudman and Bradburn: "A standard account record is used by all members. The accounting procedures used are documented both to the farmers and to the researcher. Farmers often work directly with field agents, reinforcing the standardization and the accuracy of the records" (Garcia and Sonka: 132). House points out that producer panels present a unique opportunity for proper interpretation of questions to respondents by allowing panel members to interact with one another as well as with the moderator to make sure that everyone is interpreting the questions in the same way. A comprehensive knowledge of the technical aspects of the enterprise (or firm) being analyzed is essential for developing a thorough CAR questionnaire and in administering a survey instrument. Thorough and consistent training of interviewers on the concepts being analyzed and on probing skills can go a long way to reducing the number of response errors during data collection, particularly those that relate to aspects of the operation that do not fit neatly into the designed instrument. Questionnaires sent by mail lose this aspect of quality supplied by the interviewer and therefore may be subject to more variation in the way respondents interpret questions. Dillman, however, makes a case for data collection by mailing questionnaires, and his book provides many helpful insights on how to instill quality in the design of mail questionnaires and how to achieve a reasonable response rate.

Recall Error. A second major type of response error results from the respondent's inability to recall information accurately. Two of the biggest recall problems are those of omission (forgetting to include certain items) and telescoping (including items outside the survey reference period). Omission is less likely to occur if the farm operator is asked for a list of specific expense items rather than a general question grouping types of expenses. A farmer reporting all feed expenses may omit expenses for supplements unless that is specifically listed. An appropriate time period is important if one is to minimize telescoping. In telescoping the respondent recalls and reports an expense that occurred outside the time period that the questioner intends. A farmer recalling hours of labor used during the previous four weeks may also include labor activity that occurred in the few days preceding that period, particularly if the earlier week was an active labor week. The best solution to both of these problems is to retrieve data directly from the farmer's own records. Clearly, this is the concept behind using farm records systems as a source of data for CAR analysis. However, record keeping is inconsistent among farmers and differs by type and size of farm. Johnson et al. report that approximately 70% of respondents on the FCRS used their records to answer questions on that survey. Twenty-three percent of respondents reported that they did not keep formal records of any kind.

Nonresponse Bias

When there is significant nonresponse on a data collection effort, the effect can be two-fold. First, it reduces the number of responses available for analysis, and thus reduces precision. The data collector should prepare for this situation in advance and increase the original sample size accordingly to assure that an adequate number of responses are available for analysis. Second, and more seriously, a nonresponse bias may occur if a correlation exists between the ability to get a response and the measurement of the item itself. In other words, the nonrespondents have certain characteristics different from those of the respondents, and those differences are important to the measurement of enterprise CARs. For example, if large farmers are less likely to respond in a data collection activity, the estimates from that data will be biased toward small farms and will underestimate farm size and any other variables closely related to farm size. The biases can be very serious.

Several steps are necessary to measure and control nonresponse bias. First, it is important to identify and classify reasons for nonresponse and the characteristics of these nonrespondents. Using that information, the data collector should modify data collection procedures to make them less burdensome to potential respondents and/or communicate more convincingly the reasons potential respondents should participate. The analyst should use that information to adjust rates so that the respondents more accurately represent the entire population. This concept is discussed in more detail in the section on "Reliability Issues With Analysis."

An example of this multistep approach to measuring and controlling nonresponse is the procedure used in conjunction with the FCRS (now ARMS). A special project was conducted in 1991 to identify and classify the reasons for nonresponse on this survey. The results, summarized by O'Connor, indicated that the single most frequently reported reason for refusing to respond to the survey was that the farmer was "too busy." Other reasons frequently given were that the "information requested was too personal," "that the farmer didn't like surveys," that his or her "farm records were at the tax advisors," or that "surveys and reports hurt the farmer more than help." In response to this information, data collectors began the development and testing of a shortened version of the questionnaire and developed materials to prepare interviewers to discuss concerns and grievances brought up by farmers. A separate analysis by Dillard, and then by Rutz and Cadwallader, indicated that response on the FCRS is correlated with both size and type of farm. In particular, they found that larger operators were less likely to respond on the survey. Turner and Burt quantified the size of the nonresponse bias and stated that total expenses were underestimated by approximately 10%. They began developing a procedure to group both respondents and nonrespondents by size and type classification groups, and to adjust the survey weights within those groups to allow respondents to represent nonrespondents within their classification grouping only. These procedures were successful in eliminating most of the identified bias.

Nonresponse bias exists in most data collection activities. It is important to understand that contacting only those producers likely to provide information (the approach often used in setting up producer panels or using economic engineering techniques) is, in fact, the same as excluding those unlikely to respond. Thus the potential for bias resulting from excluding producers reluctant to participate in surveys, producer panels, or record keeping services affects most data collection approaches for commodity CARs. Efforts must be made to examine the results for potential bias and adjust the estimates when necessary.

Coverage Bias

Earlier we discussed the importance of the data collector carefully defining the group or population which is to be targeted and choosing sampling and data collection procedures to assure that inferences can be made for exactly that group. When the sampled population is different from the target population, we say that coverage bias can occur. For example, a coverage problem occurs when data from a farm record system is used to make inferences about dairy farms. Willimack estimates that only 20% of dairy farms use farm record systems, and that these systems are used more often by larger farms. The question is whether that 20% can accurately represent the missing 80%.

Coverage problems may be moderated by reweighting techniques that adjust data so that it is more closely representative of the targeted population. Nonresponse, as discussed previously, can be viewed as a coverage problem. The group of respondents cannot provide inferences for the target population, which includes both respondents and nonrespondents. The solution suggested by Turner and Burt adjusts the survey weights based on classification groupings and auxiliary information. See "Appropriate Use of Weights" in the next section for more discussion.

RELIABILITY ISSUES WITH ANALYSIS

Two important issues involving analysis of data for CAR estimates are discussed in this section. The first is the appropriate use of weights in estimation and modeling to assure that the resulting estimates are representative of the enterprise being targeted. The second is the process of mixing data from different sources together to produce a single set of estimates. Beyond the material covered in this section, the appendix to this chapter contains two sections that are pertinent to the issues of data analysis. Appendix 12A provides an Overview of Statistical Sampling Techniques that can help an analyst understand the sample design which produced an existing data set. Appendix 12B provides guidelines for the appropriate rounding of estimates based on the accuracy of input data.

Appropriate Use of Weights

Weights are used with data obtained from individual farming units so that collectively those units are representative of the target population. As discussed earlier, that target population may be the entire farm sector or some designated portion of it. Weights are an essential component of data analysis regardless of whether the data come from a probability sample, a judgmental sample, or an economic engineering approach to collecting data. If weights are not used with the data, one is making the implicit assumption that each response is equally representative of the target population.

When data come from a probability survey, the weighted sum of the sample data generally will provide an estimate of the total for the item being measured. In these cases the weight is called an **expansion weight**. The survey design dictates the value of the weights. In complex designs there are different weights for each stratum and sampling stage. The weight is the inverse of the probability of selection of each unit and may be modified by poststratification and nonresponse adjustments. Expansion weights, summed by themselves across the sample, will equal the population total. **Relative weights** are often used in data analysis instead of expansion weights. Relative weights are calculated by dividing each expansion weight by the sum of all expansion weights (population total). Relative weights, summed by themselves, will always equal one. The weighted sum of the sample data, using relative weights, will provide an estimate of the mean for the item being measured.

Cost of production data frequently is produced without weights. The analyst must then decide whether he or she must develop weights to use in the analysis of this data, or whether unweighted results will be reasonable for the purpose at hand. The crucial judgment is whether each response (and there may be only one in a given data set) is equally representative of the farming enterprise being examined. If this is the case, unweighted analysis of the data set is appropriate. If not, weights must be developed.

The following is a simple example of how one could develop weights for analysis. Assume an analyst has access to cost of production data for dairy farms on a farm record system. Because data from such systems generally do not represent a cross section of the dairy farm population, the analyst needs to analyze the coverage of the data and make several judgment decisions. The data is broken into subsets of fairly homogeneous farms characterized by size, a technology index, and geographic location. Using census data supplemented by a university study quantifying the use of various production technologies within the state, the analyst produces estimates of the number of farms within the state that could be classified into each group. The estimates are constructed so that they will sum to the total number of dairy farms within the state. With these estimates, the analyst returns to the farm record data set. If the purpose is to develop cost of production estimates for each of these subgroups, the data within each subgroup can be used unweighted in the analysis. However, if there is a need to produce CAR estimates across subgroups, then the population counts developed to weight each subgroup must be used in a way that accurately reflects its relative size in state dairy production.

There are a variety of computer software packages available for analyzing weighted survey data. Most Statistical Analysis System (SAS) procedures have built-in options for using data weights. SUDAAN, available from the Research Triangle Institute, and PC CARP, developed at Iowa State University, provide options for analyzing complex survey data. Lee et al. provide a more extensive review of available computer software.

Mixing Data From Multiple Sources

It is very unusual for an analyst to derive CAR estimates from a single data source. Often there is a primary source with several secondary sources of data. The secondary data is sometimes used to produce estimates for selected activities within the enterprise. Other times the secondary data is used to develop weights for the primary data, so that the resulting CAR estimates are more representative of the target population. Census data are frequently used for this latter purpose. In particular, the economic engineering approach to developing CAR estimates generally uses a multitude of data sources to build a typical farm scenario.

Mixing different sources of data proves to be a very cost effective approach to CAR estimation. In many cases it is the only reasonable alternative. It is very important, however, to evaluate each source of data critically, both in terms of its overall quality and in terms of its compatibility with other data sources being used. Earlier parts of this chapter discussed data quality and reliability issues. Each data source should be evaluated independently in light of these issues. The composite of data sources can be no more reliable than its weakest member.

This section addresses data compatibility. Sometimes subtle differences in data sources can be important. Consider the following example. The primary data used by an analyst for CAR estimation has cost data for chemical inputs, but those costs are not broken out by individual chemical. Since a breakout is needed, the analyst gets recommendations for the use of various chemicals from an extension agent and price information from a chemical distributor. The analyst wishes to combine data from these three different sources to produce a cost breakout of chemical usage. The analyst must evaluate the inference that can be made from each data source and see if they are compatible with each other and with the overall target population about which the CAR estimates will apply. As discussed earlier in this section, the primary data must be representative of the type of enterprise targeted for the CAR estimates. Second, the recommendations from the extension agent must also be geared specifically to that same targeted enterprise, and not general recommendations for a certain commodity. Third, the price data must reflect the price structure most likely encountered by the targeted farmers. Germane to this issue would be geographic location, type of supplier, and quantity discounts. Finally, the combination of information must make sense together. The cost breakouts developed from the two secondary sources of data, when added together across different chemicals, must be consistent with the aggregates obtained from the primary data. If not, the analyst must search for the source of incompatibility before proceeding.

The above example stresses that different sources of data should target similar enterprises. Alternatively, use of secondary data for weights provides an example of when it is appropriate to utilize data sources that target a different mix of enterprises. An earlier example discussed a farm record system data for dairy enterprise information. The analyst used auxiliary census and university data for weighting and examined census data and concluded that the mix of operations (based on size, technology, and geographic location) within the data system did not mirror the actual population of dairy enterprises about which the CAR estimates were produced. Each subgroup was represented but not proportionately. The analyst was able to use the secondary sources of data to adjust the statistical inference of estimates produced using primary data. The end result was a better product.

Documentation of data sources is a critical part of the overall documentation of CAR estimation process. If multiple data sources are used, multiple sources must be documented. This documentation should outline the role of each different data source in the estimation process. For each data source, the documentation should discuss the target population of the data set and any reliability issues relevant to the estimation process.

FUTURE POSSIBILITIES

The section “Data Sources” identified the three major alternative sources of data used in developing CAR estimates. Two of those sources, probability surveys and farm record systems, deserve further consideration together. Both involve collecting data directly from a group of farm operators. Both have very distinct advantages and disadvantages as a source of CAR data. This section discusses the potential for integrating those two data collection alternatives to produce a new source of data that builds upon the strengths of its parents.

As highlighted earlier, probability surveys, such as the ARMS, can provide statistical inference for a broad array of potential target populations within the farm sector, and can provide statistical measures of precision. However, the ARMS suffers from several types of nonsampling errors, does not produce longitudinal data, and has confidentiality restrictions imposed upon the release of data records. Farm record systems contain data that are longitudinal and generally regarded as highly accurate. However, they are difficult to use for multistate analysis because procedures across states are often incompatible. Furthermore, farms included in these data sets are not representative of the farm sector, or even sizeable subsets of that sector.

Probability surveys and farm record systems each have strengths in areas where the other has relative disadvantages. Herein lies an opportunity for future possibilities: the integration of a USDA cost of production survey with a network of university farm record systems. The target population would be medium to larger farm operators engaged in specified farm enterprises. The purpose of the integrated system would be to exploit the advantages of both data sources, to combine resources and produce a single data set for access by both USDA and university analysts, and to reduce the multiple demands for financial information on the farm operator. A description of such an integrated system is outlined below.

Procedures For an Integrated USDA and University Farm Record System

1. USDA identifies long-term data components needed for federal programs. University specialists review these data components for consistency with underlying production practices, agricultural structures, and economic principles.

2. University specialists incorporate USDA data needs into farm record systems as part of a core set of variables. Individual systems include those additional data elements needed for state programs. The core will remain consistent across systems. USDA reviews system implementation for consistency.

3. USDA selects a probability sample of farm operators.

4. USDA contacts farm operators in sample, explains program and obtains cooperation. USDA subsidizes enrollment fees for participants from probability sample.

5. University specialist enrolls selected farm operators into farm record system.

6. University specialist compiles information from system and furnishes farm record data to USDA.

7. USDA provides comprehensive farm record data on a confidential basis to university specialists.

8. University specialists furnish farm business analysis and consultation to farm operators.

A project of this type would require close cooperation among universities, and between those universities and USDA. The resulting integrated system could provide a new standard of excellence in CAR data. The following table clearly displays the likely advantages. The future potential of this approach is worthy of serious consideration.

TABLE 12.1 Characteristics of Alternative Data Collection Systems

Characteristics of Data	Current USDA Survey	Current University Farm Record System	Integrated USDA and University System
Based on Probability Sampling	YES	NO	YES
Consistent Procedures Used Across States	YES	NO	YES
Data Accuracy * Accurate reporting * Detailed Information * Close local scrutiny	MODERATE	HIGH	HIGH
Longitudinal Data	NO	YES	YES
Cost	HIGH	HIGH	HIGH
Data Availability	Limited†	Varies By State	YES‡

† Currently limited to in-house use by USDA and specific collaborators on site at USDA in Washington, D.C.
‡ Could be made available to university specialists on an as-needed basis.

APPENDIX 12A

OVERVIEW OF STATISTICAL SAMPLING TECHNIQUES

This appendix provides an overview of various statistical sampling techniques, geared toward the analyst who either plans to collect primary data for CAR estimation, or who needs to understand the sample design that produced an existing data set. The overview provides limited details. Those readers desiring a more thorough discussion of these and other techniques should consult with one of the following texts that provide good introductory discussions of sampling: *Introduction to Survey Sampling* by Graham Kalton and *A Sampler on Sampling* by Bill Williams. More technical discussions are provided in *Sampling Techniques* by William Cochran and in *Sample Survey Methods and Theory* by Hansen et al.

Simple Random Sampling

This is the most basic type of statistical sampling. It involves selecting units from the population with equal probabilities, similar to drawing balls from an urn or names from a hat. An example in the context of CAR estimation: obtain a list of producers within a county, number each producer on the list and use a "random number table" to select which ones are included in the sample. Simple random sampling can be done "with" or "without" replacement, depending on whether a selected unit also can be selected on a subsequent draw (ball is replaced in the urn after it is drawn). In the CAR context, one would want to select producers "without" replacement. In practice, simple random sampling is seldom used because there are many more efficient, albeit more complex, alternatives.

Systematic Sampling

This is a variation of simple random sampling, which involves listing the population units into a random or purposeful ordering, selecting a "random start," and then selecting every "n^{th}" unit in sequence. Following the CAR example from above, if you wanted to select one out of every ten producers on the list, you would select a random number between 1 and 10 for the random start. If the random start was "3," your sample would include the producers numbered 3, 13, 23, etc.

The ordering is an important part of this sampling procedure. Random ordering will produce results similar to simple random sampling. Purposeful ordering will produce somewhat different results. For example, ordering the population by size or geographic location would force diversity within the sample. If the producer list in the CAR example had axillary information that showed acres operated, you could order the list by acres to ensure that a cross section of large, medium, and small producers would be in the sample.

Systematic sampling helps assure that the sample will adequately represent the diversity within the population. However, it does have its negative side. Undetected cycles in the ordering could lead to serious sampling bias. Systematic sample is generally operationally easier to do than simple random sampling.

Stratified Sampling

Stratified sampling forces diversity into the sample and at the same time reduces the variances of the estimates produced. The essence of this technique is to subdivide the population such that the resulting groups are fairly homogeneous regarding the attribute being measured. The groups are called strata. Each stratum is sampled separately, using a technique such as simple random sampling or systematic sampling. Stratified sampling is very common in survey sampling.

Extending the CAR example from above, you could stratify the names on the list into small, medium, and large producer groups based on acres operated. You would then sample each of the three groups, or strata, separately. The procedure would force diversity into the sample, similar to systematic sampling. Unlike that example, during estimation the variance is calculated within each stratum and then added across strata. If the operations within each group are fairly homogenous relative to enterprise CARs, the within- strata variances will be small, making the overall variances of the CAR estimates lower than under systematic sampling.

Single and Multistage Cluster Sampling

Cluster sampling is another technique in which the analyst divides the population into groups for more effective sampling. The goal is to reduce costs or save time. In stratified sampling, one samples within *each* group independently. In cluster sampling, one first selects a sample of these groups or clusters, and then, if necessary, selects units within the cluster in a second stage of sampling. Cluster samples are very effective when one does not have a complete listing of the population from which to sample.

Extending the CAR example from above, suppose the analyst wants to sample producers in the entire state instead of just a single county. It would be too costly and time-consuming to develop a list of producers in each county. The analyst first makes a list of all counties within the state. These counties represent clusters of producers. The analyst then randomly selects a sample of counties using one of the methods previously discussed. This is the first stage of the sample, and the counties are referred to as “primary sampling units.” For the *selected counties only*, a list of producers is developed. Each of these lists is sampled separately to obtain a sample of producers. This is the second stage of sampling, and the producers are referred to as “secondary sampling units.” Thus the analyst has obtained a representative sample of producers throughout the state without having to build a list of all producers.

Probability Proportional to Size Sampling

This technique is generally applied with cluster sampling. If the clusters are not the same size, and they most often are not, one may not want to give each the same chance of selection. Instead one would want to give the larger clusters, with the most secondary units, a larger chance of selection.

Extending the CAR example above, one would want to sample counties proportional to the number of producers within each county. Thus a county with twice as many producers would be twice as likely to be in the sample. However, since you do not have that information available, you could use census data to sample counties proportional to total production (of the commodity of interest).

APPENDIX 12B

GUIDELINES FOR ROUNDING CAR ESTIMATES

Consistent rounding of data and estimates expedites the analyst's comprehension of numerical data and provides an indication of the precision of the estimates. Two guidelines for rounding should be followed in publishing CAR estimates.

First, published estimates should never display greater precision than the least precise input datum. For example, the average price of a chemical input should not be published to the nearest “tenth of a cent” when the input data producing that average was received in whole cents. Likewise, the average price of purchased livestock should not be published to the nearest cent when the input prices were received to the nearest dollar.

Second, estimates should be rounded based on their overall magnitude. The following tables should be used as guidelines. The first table is for production numbers, and the second for dollars.

IF ESTIMATE FALLS IN THIS RANGE	ROUND TO NEAREST:
1 - 99	1
100 - 999	10
1,000 - 9,999	100
10,000 - 99,999	500
100,000 - 999,999	1,000
1,000,000 +	10,000

IF ESTIMATE FALLS IN THIS RANGE	ROUND TO NEAREST:
< $1.00	TENTH OF CENT
$1.00 - $9.99	CENT
$10.00 - $99.99	TEN CENTS
$100.00 - $999.99	DOLLAR
$1,000.00 - $9,999.99	TEN DOLLARS
$10,000.00 +	HUNDRED DOLLARS

CHAPTER 13

STRUCTURE AND CONTENT OF COST AND RETURN REPORTS

Producers and users of cost and return (CAR) estimates need a reporting format that enhances the ability to correctly interpret, verify, modify, update, and use the information. Preceding sections of this document have recognized that aspect of sharing CAR by providing recommendations for a wide range of documentation. This section summarizes recommended characteristics of the CAR format and provides examples. The base format includes a carefully labeled, single-page summary of the CAR and essential documentation in accompanying tables and footnotes and/or computer files. Additional suggestions for data verification, editing, updating, and sharing CAR build on these report structure recommendations.

Most CAR estimates are produced with special computer programs or spreadsheets. It is unlikely that a single program will deliver exactly the formats and supporting data recommended in this section and also meet the particular preferences of users. In recommending formats, it is assumed that CAR producers are likely to work with a variety of computer tools suited to their own situations. Specific recommendations and examples provided in this section can be adapted easily to local situations, while still maintaining the essential characteristics emphasized here.

CAR IDENTIFICATION, DOCUMENTATION, AND DESCRIPTION

Table 13.1 provides a reminder list for most of the procedural and documentary recommendations made in the various sections of this report. Details of the recommendations can be obtained from the applicable chapter or section.

The first two parts of Table 13.1 concern information needed to identify the individual CAR. A combination of the title, footnotes, and identification system (e.g., n digit code/number) needs to indicate clearly the commodity or commodities included, the applicable geographic area, a contact person or agency, the background farm situation for the CAR, and the management level assumed. Given the importance the Task Force has noted for making the distinction, a P or H should be attached to the numerical code or title to distinguish between projected and historical CARs.

Part 3 of Table 13.1 covers concepts and calculation procedures used in an individual CAR, or more likely, a whole set of CARs produced by an agency or institution. The unit of analysis, acre (hectare) definition, and production period need to be indicated on the CAR format unless the conventions used are well known. Items identified by a star (*) might most conveniently be explained in a User's Manual applicable to all of an agency's CAR estimates. The manual could be based on recommendations in this report but tailored to the specific agency situation (Texas A&M Extension Economists, for example). A fully computerized system available to both CAR builders and users could include the information either as notes or integrated tables providing data entity attributes as described later. Because a user cannot properly interpret the CAR without the starred information, every effort is needed to assure that a manual, CAR notes, or direct computer assistance is available.

Unlike part 3, parts 4 and 5 of Table 13.1 involve items unique to individual CAR estimates. In part 4, the production/marketing system is identified, and production conditions, resources, and practices are specified. If the production/marketing system is unusual, perhaps projecting a new production technology, the documentation may require special detail in explaining data estimation methods.

Part 5, Table 13.1, calls for explanations of the individual revenue and cost items. The suggestions here go beyond the units, price, quantity, and total values suggested for the single-page CAR summary formats discussed in the next subsection. Additional supporting tables and a set of footnotes or a data attribute system are also needed. The complete format with tables and footnotes is illustrated and discussed in following pages.

FORMATS FOR CAR SUMMARIES AND SUPPORTING TABLES AND FOOTNOTES

Table 13.1 indicates the scope of information needed in the overall CAR report. This section discusses and illustrates ways of providing the information. A summary CAR format, a table listing CAR items to be included in crop and livestock estimates, and supporting tables and footnotes that fulfill the specifications in Table 13.1 are suggested and discussed.

CAR Summaries

Two CAR summaries are recommended (Tables 13.2 and 13.3). Table 13.2 is a simple, one-page CAR summary with little detail, a limited list of aggregated input items, and an estimate of residual returns over included costs, properly labeled. Table 13.3 provides item units, prices, and quantities, in addition to the total values. Items are more disaggregated but the format is still one readable page. Clearly, the Table 13.2 format is most suited for a user who wants CAR values without much detail. In some cases, the Table 13.2 format may be most appropriate for composite budgets (either historical or projected) for which unit, quantity, and price data are not easily interpretable. Table 13.3 R presents the same material as is Table 13.3 but uses real values for all CARs including operating interest. The final CAR estimates are the same as when using the nominal approach in Table 13.3 since the end of the production period is the base for computing real and nominal values. Appendix 13A contains supporting tables used to produce these estimates along with a number of alternative estimates for the same enterprise using different assumptions.

Both formats have input items divided into two categories defined as follows:

1. Operating costs (costs of expendable inputs consumed during the production period).
2. Allocated overhead (costs of using capital assets that provide services over multiple production periods along with general overhead).

The first category involves input commitments for which quantities, prices, and timing can be specified a priori using knowledge of the production process being followed and expected economic conditions. The amount of the outlay and nominal interest to the end of the production period are routinely calculable and chargeable as outlined in other parts of this report. The amount of the outlay for the item is quantity used times price (e.g., current market, opportunity, use, or salvage value as discussed in other sections). In the past, "direct costs," "operating costs," "variable costs," and other names have been used in CAR formats to identify the first category of costs. ***The Task Force recommends that the term OPERATING COSTS be used as the descriptive name for these inputs.***

The second category of inputs involves own and full-time hired labor, owned machinery, equipment, buildings, livestock capital costs, and land costs that need to be calculated and allocated to individual enterprises that use them. Cash expenses for property taxes and insurance along with capital recovery (depreciation and interest) must be allocated. Other sections of the manuscript describe how these expenses/economic costs are calculated. They are allocated in the CAR estimate on a per acre or per head basis depending on use associated with the production process (e.g., based on performance rates for machinery and labor) and other estimating procedures (e.g., operator surveys and panels, expert knowledge, judgement, and logic).

Whole-farm overhead costs for items listed in Table 13.4 also need to be estimated. The recommendation is that a separate CAR table showing aggregate whole-farm overhead expenses be developed using the format presented in Chapter 9. A line is included in the allocated costs section of the CAR enterprise format so that an allocation can be made to individual enterprises, if desired. Table 13.4 suggests that individual whole-farm overhead items should be estimated separately and aggregated to the total for the CAR whole-farm overhead item. Then, the total is allocated to enterprises. An alternative is exemplified by Schedule 14.8 for the Midwest dairy farm example or Schedule 15.8 for the cotton-almond example, which allocate individual overhead cost items to enterprises. This procedure is preferred if individual items are clearly and predominantly used by certain enterprises.

The second category of input items has been called variously "Fixed Costs," "Ownership Costs," and "Economic Costs" in CAR estimates over past years. Although those names convey very useful economic and accounting concepts, the mix of items involves costs that do not meet the fixed, ownership, or economic cost definitions in every case. ***The Task Force recommends that the category heading ALLOCATED OVERHEAD be used for this group of expenses***. All of the costs in the second category are, in fact, “allocations” to the enterprise unit based on amount of use by the activity, or by other rules. They are “overhead” in the sense that they are identifiable in total at the firm level but arbitrary rules are usually used to allocate them to individual enterprises. This characteristic certainly differentiates them from items in the first input category.

Full-time hired labor and unpaid labor with farm ownership claims could possibly be assigned directly under expendables rather than being treated as allocated overhead. However, such labor will most likely require some allocation decisions by enterprise, suggesting it is probably appropriate to list it under allocated overhead. Similarly, land rent could be listed under either category, but fits more logically under allocated overhead.

CAR Items and Item Groups

Tables 13.2 and 13.3 provide an illustration of items and item groups for a dairy budget. Crop examples are presented in Chapters 14 and 15. The more detailed CAR in Table 13.3 needs to be one readable page. The one-page constraint may involve a tradeoff with detail in identifying item costs. For example, it is convenient to have fuel and lube separated from repair costs and (cash) costs for machinery, and to have insurance and taxes separated from capital recovery, but more lines would be needed. Supporting CAR information and footnotes can provide that detail, so the one-page limit priority can be met.

Tables 13.5 and 13.6 provide checklists of input items commonly included in crop and livestock CAR estimates. As indicated earlier, some sets of inputs should be disaggregated in the more detailed CAR in Table 13.3, compared to the summary CAR in Table 13.2.

Supporting Tables

Cost and return reporting formats developed over time have included several of the kinds of information recommended in Table 13.1 and they should be continued. The following supporting tables are familiar to most who work with crop and livestock CAR estimates and are a useful way to provide the supplementary information.

- A monthly calendar of tasks, operations, and inputs as illustrated in Schedule 14.5 or 15.5 should be included. This detail is essential for understanding the particular production system (activity) depicted by the CAR. The calendar makes items and values less abstract and supports user evaluation of the system's relevance. It is even useful to have a very general version of this information for a composite, historical budget.

- A supporting table should provide details of cost items that may be masked by aggregations across tasks, machines, and cost items in the one-page summary CAR. Schedule 14.5 in the Midwest farm example or Schedule 15.5 in the cotton-almond example provide illustrations of what is needed. It might be feasible to combine the monthly calendar and the input cost information, including operating and ownership costs by operation and individual chemical applications, and so forth.

- A list and description of machinery and equipment used in developing the CAR estimate along with data required for the cost calculations (e.g., purchase price, years of life, use per year, and applicable engineering cost equation coefficients) should be attached. It may be convenient to assign machine codes in this table for use in identifying machinery and equipment items throughout the CAR format. The machinery and equipment information might support a large set of CARs from a given producing agency. For example, all CARs applicable to a particular farm type and geographic area might be covered by one machinery and equipment set table. Examples of equipment and machinery lists are provided in Schedules 14.6, 14.7, 15.6 and 15.7.

- Tables summarizing input and product price assumptions for sets of CAR are recommended. An alternate approach is through notes or data attribute information discussed in the next subsection. Price sources and data treatment (e.g., methods of handling price variability) should also be described. It is useful to have the comparisons of prices across commodities and inputs in one table. If users understand the initial, carefully considered prices used in CAR, they are less likely to substitute inferior price assumptions. Or, they have a better basis for adjusting prices for their own situation. The footnotes to Table 13.3 and Table 13A.8 provide a clear summary of the price assumptions.

Footnotes

A series of footnotes or computerized data attributes to provide information for Table 13.1 items that cannot be presented fully in the single-page summary and supporting tables is recommended. Footnotes should be referenced to items in the one-page, detailed CAR. The footnote documentation is the core of Task Force intent to increase user understanding, allow for replication (verification) and validation of the CAR values, supply data references and information about actual and possible other assumptions, increase flexibility in CAR use, and generally afford improved CAR quality control.

Examples of footnote/data attribute information (and references as appropriate) are provided by the notes attached to Table 13.3 and Table 13.3R. The notes may perform any or all of the following tasks.

- Describe type, size, managerial level, and other assumptions concerning the whole farm that are (at least implicitly) in the background for the CAR.

- Provide current, specialized information about the particular enterprise. For example, details of a government farm program affecting price and acreage of the commodity could be explained. These details could be kept up to date and used to update the CAR using the underlying computer system. Thus the user would know how government program effects on the enterprise were handled.

- Present price and yield data series supporting the values used in the CAR, with source references. If this series were operational, it would replace the price assumptions table suggested earlier.

- Provide information to assist the user to modify the CAR for other planning situations such as a different irrigation or feed/pasture system, custom rather than own harvesting equipment, a different quality of soil or farm location, a different size of farm unit, or an alternative level of a critical variable input. The resulting flexibility afforded for using each CAR could cut down on the number of CARs provided by an agency.

- Contain additional detail on chemicals (analysis, generic names, etc.), fertilizer mixes, seeding and reseeding costs, miscellaneous supplies included for crops and livestock, vet and med costs, various complicated cost calculations, and so forth.

- Present sensitivity analysis for variables in the CAR. The most common sensitivity analysis provided for CAR is a simple matrix of residual returns for arbitrary ranges of yields and prices about the base levels in the CAR. Sensitivity of returns to changes in other key variables might also be presented. As noted in an earlier section, relationships (e.g., meaningful correlation) among the variables should not be ignored in choosing the ranges for sensitivity analysis.

DATA VERIFICATION, EDITING, UPDATING, AND SHARING

The CAR format with accompanying documentation is designed to present data clearly and provide detail needed for thoughtful use. It anticipates a subsequent process of data verification, editing, updating, and sharing by CAR users. This process has varied levels of complexity depending upon the intended use of the CAR information, the methods used to collect, tabulate, and analyze the data, and the desirability and need for sharing with others.

No single CAR meets the needs of all users, necessitating the need for flexibility and adaptability. Hallam discusses three broad classes of users: economic optimizers (or managers), economic analysts, and policy evaluators. The optimizers include firm-level agricultural producers, consultants who provide assistance to decision makers, and researchers evaluating alternative technologies. Economic analysts use CAR to test hypotheses and make predictions of economic responses. This includes supply and demand analysis and work on the structure of agriculture and the organization of firms. Those evaluating policy typically aggregate firm-level data that begins with individual enterprise CARs (Hallam: 373). As discussed in Chapters 1 and 2, different methods may be appropriate for these different uses. In addition, different formats for presenting and sharing the data may be useful. The best way to share historical data based on surveys may differ from the best way to share data that is used to create projected CAR estimates. Given that CAR may be developed for one particular purpose, the procedures recommended in this chapter on report format and handling data may assist users in modifying estimates for use in another purpose, while maintaining the recommended CAR properties.

Partly because CAR producers as well as users have varied objectives, published CARs may have important differences. For example, conducting a major survey of producers of a particular commodity to determine CARs for making policy decisions involves a different process than using a local farmer panel to determine CARs for farm-level planning. In the case of the survey, major efforts will be devoted to conducting the survey, computer coding and verifying the data, developing appropriate statistical techniques to summarize the data, and developing reports that can be used by the policy maker. The use of the farmer panel is usually less structured and the results obtained are only a “starting point.” Numerous adjustments must be made when doing planning for an individual producer. The recommended CAR estimation methods, format, and documentation are designed to give the prospective user of diverse CARs a well defined starting place to verify, edit, update, and share various CARs.

Because of the diversity identified above, it is highly unlikely that a single method for data verification, editing, updating, and sharing can be utilized. Nevertheless, through standardized concepts and procedures, significant progress can be made in those activities. To that end, the terms EDITING, VERIFICATION, MODELBASE, FORECAST, AND UPDATING are defined here and in the glossary of this report.

Editing is the process of changing one or more coefficients used in a specific CAR budget.

Verification is the process of confirming that the data used in the calculations were, in fact, the data the user intended to use.

Modelbase is the set of equations and the specified calculation procedures that are used to manipulate/use a database, for example, a CAR modelbase.

Forecast is the projection of CAR for some future period based on expected input-output coefficients and a set of prices. The procedures recommended by the Task Force will primarily be used for planning or analysis of expected response. The resulting CAR estimate can therefore be defined as a forecast of expected CARs based on documented input-output relationships and prices.

Updating is the process of changing the data used in making the CAR estimate. As new data becomes available, users will want to replace the obsolete data. "Updating," as used in this report, refers to the data rather than the calculation procedures and specified input-output relationships.

In addition, a procedure is outlined in Appendix 13B to make CAR data and documentation available in electronic form. This computerized approach would provide consistency, simplicity, convenience, and flexibility in editing, verifying, and updating CAR data.

In order to meet the objective of sharing CAR data, a database of available CAR estimates is needed. An inventory of both CAR data and methods could be obtained through a sharing of information by those who conduct CAR studies. The database of the shared CAR data should be computer coded and the data file accessible and able to be downloaded using compatible software and data formats.

Data sharing is complicated by problems concerning software and data compatibility. Not all software packages have identical data requirements or use the same data formats. No recommendation is made here about which specific software packages or formats should be used; however, the unequivocal requirement is that data files contain not only data values of interest but also documentation about the data. Data documentation includes variable names, labels, and alphabetic characters or numeric values in a specified format. Format documentation includes physical characteristics and field specifications or locations of the data in the file. Because the format determines how easily data can be shared, this information is very important to potential data users. Software packages are available to translate data stored in one format to another format. General data documentation might include information, restrictions, or assumptions about the data that would assist the user in interpretation and use. The terms DATA FILE, SOFTWARE, AND FORMAT are defined here and in the glossary of this report.

Data file is the complete collection of variables, data values, and so forth that are needed to use the data meaningfully.

Software is one program or a collection of programs (package) designed for a specific purpose. For example, LOTUS 123 is a spreadsheet software package. Data created by software packages generally hold compressed data and formatting codes that control how they will be displayed on a screen or printed.

Format is a set of directions that describes a field or location and the contents of that field to help the computer to read and write data values.

Recommended Methods for Data Sharing

The use of the INTERNET is recommended for the exchange of data and information related to CAR budgets in electronic form. The INTERNET is a worldwide collection of interconnected computer networks that link academic institutions, the research community in the government and private sectors, general businesses, and individual consumers.

The INTERNET enables exchange of data in the most efficient manner through electronic mail, the World Wide Web, file transfer, or remote login. Electronic mail may be the most versatile of these four, because it most readily translates information between different communication protocols in the various networks. This may also be applicable in transferring data from a WINDOWS to a UNIX computer. However, encoding and decoding packages such as ABE (Ascii Binary Encodes) might be needed to move binary files by electronic mail. Pages on the World Wide Web may be used to provide access to specific data files. An individual accessing a particular homepage could be given instructions on downloading a data file or could simply download some types of files by clicking on an icon. The File Transfer Protocol (FTP) moves files from one computer to another. Access to the files is subject to the standard computer security protection, e.g., in UNIX installations, the user has to be authorized for read-access to the files to be transferred. The user will remain barred from modifying or deleting files on the host computer. The INTERNET remote login program (TELNET) allows a user to work on a computer that is located hundreds of miles away, but it requires that the user be registered on the host computer. TELNET may also be used to transfer files.

The optimal way to provide information regarding the availability of specific CAR for use by others is a problem that must be addressed. One possible solution is to set up a central registry of available CARs, with continuous updating. The datafile ENTRPRSE discussed in Appendix 13B could serve as the central registry. This approach relies on the willingness of each researcher to add new developments to the registry; it also relies on a volunteer to take custody of such a central registry. This option would not require the complete transfer of the budget information to the registry, rather, only the provision of access information (or links). The transfer of all completed CARs into some central file would be an alternative; this alternative would require a custodian of the massive resulting file structure. In light of the cooperative nature of the effort, the first alternative is preferable.

TABLE 13.1 Recommended Items for Individual CAR Identification, Documentation, and Description[1]

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1. Identification of the CAR

   a. CAR name (usually refers to a commodity), and code if appropriate.
   b. Historic or projected.
   c. Preparer, contact person, agency, phone, e-mail address, etc.
   d.* Software used to generate CAR.
   e. Date CAR estimate prepared.

2. Assumptions concerning the setting for the CAR

   a. Identification of the country, county, state, province, or other subarea to which the CAR is applicable.
   b. Description of the individual or composite farm situation that provides the background for the CAR estimate, including the farm size, type, and business organization.
   c.* Specification of the management level assumed.

3. Concepts and procedures followed in CAR estimation

   a. Unit of analysis (acre, head, farm, etc.).
   b. Planted or harvested acre.
   c. Starting and ending dates of production period.
   d.* Time point for discounting values (e.g., harvest time).
   e.* Interest and discount rates used (e.g., real v.s. nominal).
   f.* Handling costs and returns from government programs.
   g.* Method of handling variability in estimates (trends, cycles, seasonality, and random variation).
   h.* Handling, storage, and processing CARs when applicable to a given CAR.
   i.* Method used to measure and cost pasture.
   j.* Opportunity and market costing methods utilized.
   k.* Land costing method.
   l.* Labor costing method.
   m.* Method used to allocate overhead costs.
   n.* For international CAR comparisons, inflation and exchange rates assumed, policy distortions among the subject countries, excluded or unaccounted costs among the estimates, etc.
   o.* Standardized machinery and equipment costing procedures, perhaps incorporated in the computer program used.
   p.* Method used to calculate interest charges on operating capital.

TABLE 13.1 (continued)

4. The production/marketing system assumed

   a. A description of the product(s) and services produced and an indication of the marketing plan (timing/location of sale, market type, pricing approach) assumed.
   b. Specification of the technical production conditions and practices such as soil type and class, irrigation (indicate system), organic practices, formal rotations, row spacing, preceding and following crops, machinery and equipment set assumed, machine use per year, feeding plan, animal replacement practices, animal grades/varieties used, and chemical/cultural approach.
   c. Explanation of the data estimation methods for nontraditional or new technology included in CAR.

5. Explanation of individual revenue and cost items

   a. Yield and product price bases and sources. Explanation of how the yields used relate to yield data cited and how prices used relate to yields and product qualities used.
   b. Levels of expendable inputs and prices. Examples include the nature of inputs used (e.g., active material in fertilizer and chemicals by generic and brand names), seeding and reseeding rates and times, assumptions regarding death and shrink losses, feed consumed, routine medication and veterinary medical treatments, pasture calculations, miscellaneous supplies, breeding fees, etc.
   c. Methods used for estimating the costs of multiple year production activities (e.g., providing replacement cows, re-establishing alfalfa, orchards, etc.).
   d. A review of data sources.

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[1]Items identified by *, and perhaps some others that are consistently handled across agency CAR, can best be handled in a CAR manual and/or computer HELP command.

TABLE 13.2 A Sample One-page CAR Summary for a Dairy Budget
1992 Projected Costs and Returns for Milk Production Per Cow, Brief
(Rearing of replacement heifers not included)
Ben & Bev Dairyman Farm, Upper Midwest, USA (See Chapter 14 for a complete description of the farm)
Prepared by John Q. Taskforce, Dept. of Ag. Econ., Anonymous State University, March 1992

Item	Dollars
Gross Value of Production:	
Milk	$2,652.04
Cull Cows	0.00
Bull Calves	51.00
Heifer Calves	61.20
Interest on Receipts to December	113.44
Total	2,877.68
Operating Costs	
Replacement Heifer	0.00
Corn	278.47
Protein, Vitamins, & Minerals	190.29
Alfalfa Hay	172.09
Alfalfa Haylage	174.59
Corn Silage	64.96
Marketing	103.33
Breeding	46.80
Veterinary & Medicine	64.52
Supplies	156.00
Fuel, Oil, and Utilities	26.58
Repairs	302.15
Bedding	
Interest On Operating Inputs To December	65.09
Total Operating Costs	1,644.87
Allocated Overhead	
Hired Labor	258.30
Opportunity Cost Of Unpaid Labor	243.45
Opportunity Interest Of Labor	20.67
Capital Recovery Of Livestock Investment	247.96
Capital Recovery Of Machinery & Equipment Investment	86.82
Capital Recovery Of Bldg Investment	74.04
Taxes & Insurance	11.23
General Farm Overhead	99.46
Total Allocated Overhead	1041.93
Total Costs Listed	2,686.80
Value Of Production Less Total Operating Costs	1,232.81
Value Of Production Less Total Costs Listed	190.88

Table 13.3 A Sample Detailed CAR Summary for a Dairy Budget
1992 Projected Costs and Returns for Milk Production Per Cow, Detailed
(Uses capital recovery to account for cost of replacement heifers)
Ben & Bev Dairyman Farm, Upper Midwest, USA (See Chapter 14 for a complete description of the farm)
Prepared by John Q. Taskforce, Department of Agricultural Economics, Anonymous State University, March 1992

	Item	Units	Quantity	Price	Value
	Gross Value Of Production				
1	Milk (a)	cwt	216.00	12.28	2,652.04
2	Cull Cows (b)	cwt	4.68	45.56	0.00
3	Bull Calves (c)	hd	0.42	122.78	51.00
4	Heifer Calves (c)	hd	0.42	147.34	61.20
5	Interest On Receipts to December (d)			0.092	113.44
6	Total (e)				2,877.68
	Operating Costs				
7	Replacement Heifer (f)	hd	0.40	1031.36	0.00
8	Corn (g)	bu	135.00	2.06	278.47
9	Protein, Vit., & Min. (g)	cwt	12.72	14.96	190.29
10	Alfalfa Hay (g)	ton	2.19	78.58	172.09
11	Alfalfa Haylage (g)	ton	2.37	73.67	174.59
12	Corn Silage (g)	ton	3.96	16.40	64.96
13	Marketing (milk) (h)	cwt	216.00	0.48	103.33
14	Breeding (i)	cow	1.00	46.80	46.80
15	Veterinary & Medicine (i)	cow	1.00	64.52	64.52
16	Supplies (i)	cow	1.00	156.00	156.00
17	Fuel, Oil, & Utilities (j)				26.58
18	Repairs (k)				302.15
19	Bedding				
20	Interest On Oper. Costs To Dec. (d)			0.092	65.09
21	Total Operating Costs (e)				1,644.87
	Allocated Overhead				
22	Hired Labor (l)				258.30
23	Opportunity Cost Of Unpaid Labor(l)				243.45
24	Opportunity Interest on Labor				20.67
25	Capital Recovery Of Livestock Investment (m)				247.96
26	Capital Recovery Of Mach & Eq Investment (n)				86.82
27	Capital Recovery of Bldg Investment (o)				74.04
28	Taxes & Insurance (p)				11.23
29	General Farm Overhead (q)				99.46
30	Total Allocated Overhead (e)				1,041.93
31	Total Costs Listed (e)				2,686.80
32	Value Of Prod. Less Total Oper. Costs (e)				1,232.81
33	Value Of Prod. Less Total Costs Listed (e)				190.88

TABLE 13.3: 1992 Projected Costs and Returns for Milk Production Per Cow, Detailed Notes
(Table 13A.1 contains cost and revenue data by month for the dairy enterprise.)

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[a] Quantity sold is the total for the year; sales each month are 18 cwt. Price per cwt for milk is based on a non-seasonally adjusted real average price at the end of the year of $12.50. This was adjusted using the seasonal index below to account for typical seasonality in milk prices and then adjusted to a nominal basis assuming a 4% annual rate of inflation. The nominal at the end of the year is $12.50, because this is the base period. The average nominal price for the year is projected to be $12.278. Nominal interest on this revenue from the month of sale to December 31 is recorded on line 5. It is assumed that revenue from milk is received at the end of the month. Because quantities per month are constant, the average nominal price for the year multiplied by the total quantity gives the actual total revenue (expenditure).

	Jan	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**July**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Average**
Seasonal Index	103.0	101.8	100.0	98.4	96.8	95.7	96.4	97.7	100.3	102.7	103.8	103.3	100.00
1992 Real (seas. adj.)	12.875	12.725	12.500	12.300	12.100	11.963	12.050	12.213	12.538	12.838	12.975	12.913	12.500
1992 Nominal	12.420	12.316	12.138	11.983	11.826	11.730	11.855	12.054	12.415	12.754	12.933	12.913	12.278

[b] Dairy cows are assumed to be replaced every 2.5 years giving a replacement rate of .40. It is assumed that 1% of the cows die each year (2.5% over the 30-month period) and thus are not available to be sold. This gives an effective cull rate of .39 [0.40 - 0.01 or (0.975)(0.40)]. The average weight of the .39 cows culled per year is 1,200 pounds. This gives per cow culled sales of 468 pounds [(.39)(1,200)]. Price per cwt for cull cows is based on a nonseasonally adjusted real average price at the end of the year of $46.40. The seasonally adjusted price is $42.8736 which is both a real and nominal value for December 31. This was adjusted to a nominal basis assuming a 4% annual rate of inflation with the end of December being the base point in time. The average nominal price over the 12 months is $45.56. Nominal prices for each month are reported here and in Table 13A.8.

Seasonally Adjusted Nominal Prices	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**July**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Average**
Cull Cows	42.97	46.30	47.53	47.15	47.16	46.18	45.88	46.35	46.18	45.08	43.06	42.87	45.56
Bull Calves	120.59	120.98	121.38	121.77	122.17	122.57	122.97	123.38	123.78	124.19	124.59	125.00	122.78
Heifer Calves	144.70	145.18	145.65	146.13	146.61	147.09	147.57	148.05	148.54	149.02	149.51	150.00	147.34

Because the estimate in Table 13.3 uses the capital recovery method to value investment in the breeding herd, no income from cull sales is included in the estimates. The value of the cull animal is included as a negative cost in computing the cost of a breeding herd replacement in line 25 of Table 13.3.

[c] The calving interval is 13 months, producing 0.92 (12/13) calves per year. With a livability of 90%, this results in 0.4154 [(12/13)(0.9)(0.5)] bull calves and 0.4154 heifer calves per year.

The prices for calves reflect the market in the area for 3-day-old calves and is assumed to have a constant real value during the year. The real and nominal values are projected to be $125 for bull

TABLE 13.3 Detailed Notes (continued)

calves and $150 for heifer calves on December 31, 1992. Nominal prices for each month are contained in Table 13A.8 and in the Table in footnote [b]. The average nominal values are $122.78 and $147.34. As with the cull cows, the calf sales are assumed to be equally spaced during the year.

[d] All receipts and expenses are assumed to occur on the last day of the month. Interest is compounded at the monthly rate of .00736 $\left[(1.092)^{\frac{1}{12}} - 1\right]$, (equivalent to an annual rate of .092) until the last day of December. For example, the interest income on milk receipts on January 31 of 223.556 is $18.7841 $[(223.556)(1.092)^{11/12} - 223.556]$. We do this for each month and for each revenue category and sum them.

[e] Individual values may not sum to totals due to rounding.

[f] Dairy cows are assumed to be replaced every 2.5 years giving a replacement rate of .40. The cull rate of .39 allows for some death loss over the life of the cow. A real price of $1,050 per replacement as of December 1992 is assumed. This gives a nominal price at the beginning of January 1992 of $1,009.6155 [(1,050)/(1.04)]. This is adjusted each month to reflect 4% inflation during the year. Thus the price at the end of January is $1,012.92 $[(1,009.6155)(1.04)^{1/12}]$. The nominal prices per month are reported in Table 13A.8. with a nominal average during the year of $1,031.36. Because this estimate uses the capital recovery method for valuing the investment in the herd, no replacement cost is included on line 7 of the report. The value of the replacement is included in computing the cost of a breeding herd replacement on line 25 of Table 13.3.

[g] Annual feed consumption is 135 bushels of corn, 1,272 pounds of a protein/vitamin/mineral premix, 2.19 tons of alfalfa, 2.37 tons of alfalfa haylage, and 3.96 tons of corn silage. These annual consumption amounts are based on historical data for the Dairyman operation and information on ration formulation available from the Minnesota Extension Service. This gives per day amounts as follows: corn (20.712 lbs), vitamin mineral premix (3.485 lbs), alfalfa hay (12 lbs), alfalfa haylage (12.9863 lbs), and corn silage (21.6986 lbs). The prices in Table 13.3 are the nominal averages for the year and reflect net market prices the farm would receive. The prices are not seasonally adjusted. The monthly prices are as follows.

	Jan	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**July**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Nominal Average**	**Real Average**
Corn	2.03	2.03	2.04	2.05	2.05	2.06	2.07	2.07	2.08	2.09	2.09	2.10	2.06	2.10
Premix	14.69	14.74	14.79	14.84	14.89	14.93	14.98	15.03	15.08	15.13	15.18	15.23	14.96	15.23
Alfalfa Hay	77.17	77.43	77.68	77.94	78.19	78.45	78.70	78.96	79.22	79.48	79.74	80.00	78.58	80.00
Alfalfa Haylage	72.35	72.59	72.83	73.06	73.30	73.54	73.78	74.03	74.27	74.51	74.76	75.00	73.67	75.00
Corn Silage	16.11	16.16	16.22	16.27	16.32	16.38	16.43	16.48	16.54	16.59	16.65	16.70	16.40	16.70

TABLE 13.3 Detailed Notes (continued)

[h] Based on the expenditures by the farm through marketing 216 cwt of milk in 1991 for \$99.36. This is equivalent to an average of \$0.46 per cwt. This is adjusted forward to a nominal yearly average price for 1992 of \$0.4784, giving a projected annual nominal cost of \$103.3344. To account for monthly expenditures and operating interest we need to allocate these annual amounts over the months. Since Ben markets the same amount of milk each month this is most easily done by assuming that real expenditures are constant. We can find a constant real price per month using the monthly inflation rate and the fact that the nominal monthly expenditures must add up to total nominal expenditures where sales per month are 18 cwt. This gives $\sum_{j=1}^{12} p_j^n (18) = \sum_{j=1}^{12} p^r (1+\pi_m)^{j-12} (18) = (.46)(1.04)(216) = (.4784)(216) = 103.3344$. We solve this expression for p^r to get the constant real price per cwt. Letting EXP_{-1} be total nominal expenditures last year and assuming the end of December of the current year is the base for computing real values we obtain

$$\sum_{j=1}^{12} p^r (1+\pi_m)^{(j-12)} (18) = (1+\pi) EXP_{-1}$$

$$\Rightarrow p^r = \frac{(1+\pi) EXP_{-1}}{(18) \sum_{j=1}^{12} (1+\pi_m)^{(j-12)}} = \frac{(1+\pi) EXP_{-1}}{(1+\pi_m)(18) \sum_{j=1}^{12} (1+\pi_m)^{(j-12-1)}}$$

$$= \frac{(1+\pi) EXP_{-1}}{(1+\pi_m)(18)\, US_0(\pi_m, 12)}.$$

The last equality comes from equation 2B.7. Writing the expression this way allows the use of canned annuity procedures for computing p^r because the last expression is just the annuity having a present value of $(1+\pi)EXP_{-1}$ divided by $(1+\pi_m)(18)$. Monthly real expenditures are $(18)p^r$ while monthly nominal expenditures in the j^{th} month are $p^r (1+\pi_m)^{j-12} (18)$. For this example we obtain

$$p^r = \frac{(1+\pi) EXP_{-1}}{(1+\pi_m)(18)\, US_0(\pi_m, 12)}$$

$$= \frac{(1.04)(99.36)}{(1.0032737)(18)(11.748502)}$$

$$= \frac{103.3344}{212.165335}$$

$$= .4870.$$

This is the real price (also equal to the nominal price on December 31st) that can be adjusted for inflation to create a nominal price for each month of the year. The simple average of these constructed nominal prices will be the projected nominal average for the year (\$0.4784). An alternative would be to assume that nominal prices are equal each month and are equal to \$0.4784. This would give constant nominal expenditures per month of \$8.6112 as compared to the rising pattern in Table 13A.1.

TABLE 13.3 Detailed Notes (continued)

[i] Based on total nominal expenditures as recorded in farm records for these livestock inputs in 1991 on a per cow basis. Total expenditures are adjusted forward assuming a 4% inflation rate. Ben did not have data on monthly allocations but felt that they were approximately equal each month for the dairy operation. We therefore assumed that the real expenditures per month are equal for 1992. This means that expenditures rise at the monthly rate of inflation from the end of January to the end of December. Specifically, we solve for a constant real monthly amount (a) such that

$$a(1+\pi)^{-\frac{11}{12}} + a(1+\pi)^{-\frac{10}{12}} + \quad + \quad + a(1+\pi)^{-\frac{0}{12}} = a\sum_{j=1}^{12}(1+\pi)^{\frac{(j-12)}{12}} = (1+\pi)\,EXP_{-1}$$

where EXP_{-1} is total nominal expenditures last year and the end of December of the current year is the base for computing real values. Breeding expenditures for 1991 were $45.00. Inflation adjusted expenditures are then $46.80. We can use the standard present value functions to find the real payment (a) by noting that it is given by

$$a = \frac{(1+\pi)\,EXP_{-1}}{\sum_{j=1}^{12}(1+\pi)^{\frac{(j-12)}{12}}} = \frac{(1+\pi)\,EXP_{-1}}{\sum_{j=1}^{12}(1+\pi_m)^{(j-12)}} = \frac{(1+\pi)\,EXP_{-1}}{(1+\pi_m)\sum_{j=1}^{12}(1+\pi_m)^{(j-12-1)}} = \frac{(1+\pi)\,EXP_{-1}}{(1+\pi_m)\,US_0(\pi_m, 12)}$$

where π_m is the monthly inflation rate computed from 2.12. The last expression is obtained using equation 2B.7 and is just the annuity having a present value of $(1+\pi)\,EXP_{-1}$ divided by $(1+\pi_m)$ and is discussed further in equation 5.14 on allocating repair costs. It is easy to compute using standard functions such as PMT in Excel. For example, the real breeding cost is given by

$$\begin{aligned} a^{r}_{breeding} &= \frac{(1+\pi)\,EXP_{-1}}{(1+\pi_m)\,US_0(\pi_m, 12)} \\ &= \frac{(1.04)(45)}{(1.0032737)(11.748502)} \\ &= \frac{46.8}{11.78696} \\ &= 3.97048. \end{aligned}$$

This is the real (and also nominal) payment in December, the nominal payment in November is $3.9575 $[(3.9705)(1.04)^{\frac{-1}{12}}]$, the nominal payment for January is $3.8303, and so forth. Veterinary and medicine in 1991 were $62.04, while supplies were $150, giving 1992 total nominal expenses

TABLE 13.3 Detailed Notes (continued)

of $64.52 and $156. The December monthly payments are $5.47 and $13.23 in both real and nominal terms. The nominal payments for earlier months follow the pattern in Tables 13A.1 and 13A.8.

[j] Data in Schedule 14.8 indicate $2,275 [(3,500)(.65)] of expense for 89 cows, or $25.56 per cow for fuel, oil, and utilities. It is assumed that these are spaced equally throughout the year for the purpose of computing operating interest. Like the items in footnote [i], this expenditure is adjusted for inflation and then allocated across months such that real expenditures per month are equal. The real expenditure per month is $2.2554. Monthly nominal expenditures are summarized in Table 13.A.1. Average nominal expenditure is $26.58 [(25.56)(1.04)].

[k] Annual Repairs for Buildings and Equipment for Dairy Cows

All repair costs are computed using list prices, which are assumed to be 10% higher than the market value. Repair costs per year are calculated using equation 5.8 $\left(C_{rm\,t} = (RF1)(P_t)\left(\frac{h_t}{1,000}\right)^{RF2} \right)$

assuming a list price for the manure equipment of $40,780 at the beginning of the year, a useful life of 12 years, and an assumed annual use of 200 hours. The computation is as follows where the inflation rate is assumed to be 4%.

$$C_{rml2}(manure) = (0.63)((40,780)(1.04))\left(\frac{2,400}{1,000}\right)^{1.3} = 83,386.496 \text{ for the total of } 2,400 \text{ hours of use},$$

which gives a cost per hour of (83,386.496/2,400) = $34.744.

For feed equipment the repair cost is computed as

$$C_{rml5}(feed) = (0.15)((27,331)(1.04))\left(\frac{1,995}{1,000}\right)^{1.6} = 12,873.266 \text{ for the total of } 1,995 \text{ hours of use},$$

which gives a cost per hour of (12,873.266/1,995) = $6.4527.

For milking equipment the repair cost is

$$C_{rml5}(milk) = (0.007)((30,442)(1.04))\left(\frac{16,500}{1,000}\right)^{2} = 60,335.435 \text{ for the total } 16,500 \text{ hours of use},$$

which gives a cost per hour of (60,335.435/16,500) = $3.6566.

Costs for the other items are computed using the previous year’s expenditures adjusted for inflation (4%).

TABLE 13.3 Detailed Notes (continued)

		Annual Expense	Percent for Cows	Repairs for Cows
Manure Equipment (Schedule 14.7)	($34.744/hr x 200 hr)	$6,948.87	80	$5,559.10
Feed Handling Equipment (Schedule 14.7)	($6.4528/hr x 133 hr)	858.22	80	686.57
Milking Equipment (Schedule 14.7)	($3.6567/hr x 1100 hr)	4,022.36	100	4,022.36
Repairs to Dairy Building (Schedule 14.6, footnote d)	($10,524 in 1991)	10,944.96	100	10,944.96
Buildings & Improvements (Schedule 14.8)	($7,165 in 1991)	7,451.60	65	4,843.54
Machinery & Equipment (Schedule 14.8)	($1,235 in 1991)	1,284.40	65	834.86
				26,891.40
		Estimated repairs per cow (89)		$302.15

Ben does not have any data on the allocation of repair expenditures over the year. After discussion with him, it was decided to assume that the total real repair expense was spaced equally throughout the year for the purpose of computing operating interest. As suggested in Chapter 5, because the repair costs are in nominal (also real) values at the end of the year and expenditures will be at an earlier point in time, it is appropriate to deflate these before computing nominal interest. The procedure suggested in [i] and [j] is followed to find a constant real payment, which is then adjusted for inflation. The computations are contained in Table 13A.1 and are repeated here.

Real Prices	**Real Cost Per Month**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**July**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Average Cost**	**Current Cost**
Cow Repairs (Real)	25.6343	25.63	25.63	25.63	25.63	25.63	25.63	25.63	25.63	25.63	25.63	25.63	25.63	25.63	**302.1505**
Replacement Repairs (Real)	2.7974	2.80	2.80	2.80	2.80	2.80	2.80	2.80	2.80	2.80	2.80	2.80	2.80	2.80	**32.9727**
Cow Repairs (Nominal)		24.73	24.81	24.89	24.97	25.05	25.14	25.22	25.30	25.38	25.47	25.55	25.63	25.18	**302.1505**
Replacement Repairs (Nominal)		2.70	2.71	2.72	2.73	2.73	2.74	2.75	2.76	2.77	2.78	2.79	2.80	2.75	**32.9727**

[l] Livestock labor is based on labor use in 1991 (Schedule 14.4) and an interview in which Ben allocated the labor between the cows and the young stock. The data is as follows.

Worker	**Total Livestock Hours**	**Total Cows Hours**	**Total Young Stock Hours**	**Per Cow Hours**	**Wage $/hour 1991**	**Wage $/hour 1992**	**Per Cow Cost**
Operator	2,437	2,193	244	24.640	$9.50	$9.880	$243.45
Son	330	0	330	0.00	$5.43	$5.645	$0.00
Hired Worker 1	2,173	1,956	217	21.978	$9.47	$9.845	$216.38
Hired Worker 2	734	661	73	7.427	$5.43	$5.645	$41.92
Total Hired							$258.30

TABLE 13.3 Detailed Notes (continued)

The implicit 1991 wage rates for hired workers are computed from the data in Schedule 14.4. The son's labor is priced the same as Hired Worker 2. The operator has an opportunity wage of $9.50. Unfortunately no data on the monthly breakdown of labor use by month was available. Therefore it was assumed that labor use for the dairy operation was the same each month. Whereas this would be obviously incorrect for most crop operations, it is probably reasonable for the dairy operation. The implicit cost per hour for 1992 was computed by multiplying the 1991 wage rates by 1.04 to account for inflation. It is assumed that labor quantities in 1991 and 1992 are the same. The labor expenditures (such as hours) are assumed to be equally spaced over the year so that each worker (including the unpaid ones) is paid a monthly salary. These expenditures are allocated in a manner similar to items in footnotes [h], [i], and [j] where a constant real payment over the months is assumed. The actual monthly expenditures in real and nominal terms are as follows.

Expenditure	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**July**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Average**	**Total**
Month #	1	2	3	4	5	6	7	8	9	10	11	12		
Family Labor Real	20.65	20.65	20.65	20.65	20.65	20.65	20.65	20.65	20.65	20.65	20.65	20.65		243.448
Family Labor Nominal	19.92	19.99	20.06	20.12	20.19	20.25	20.32	20.39	20.45	20.52	20.59	20.65	20.29	243.448
Hired Labor Real	21.91	21.91	21.91	21.91	21.91	21.91	21.91	21.91	21.91	21.91	21.91	21.91		258.300
Hired Labor Nominal	21.14	21.21	21.28	21.35	21.42	21.49	21.56	21.63	21.70	21.77	21.84	21.91	21.53	258.300
Opportunity Interest	3.45	3.14	2.82	2.51	2.19	1.88	1.56	1.25	0.94	0.62	0.31	0.00		20.672

The nominal average expenditure multiplied by 12 will give the nominal expenditure for the year. Opportunity interest at a nominal rate is charged since most employees are paid monthly and the family makes monthly withdrawals.

[m] Capital recovery is based on the difference between the real market value of a bred heifer, $1,050, (assumed purchased at the beginning of the current year) and the real sale value of a 1,170 pound cull cow at $46.40 per cwt., or $542.88 received three years later. The 1,170 pounds represents 2.5% less than 1,200 pounds to account for death loss. This sale value is discounted back to the present at a real interest rate of 5% and then subtracted from the purchase price of the heifer to obtain a net present cost of the breeding animal. This is then converted to a real 30-month annuity following the procedures outlined in Chapter 2. This real annuity is adjusted back to each month of the year to account for inflation during the year. Specifically,

$$a^r(monthly) = \$20.2042 = \frac{\left(1,050 - \frac{542.88}{(1.05)^{30/12}}\right)}{\left(\frac{1 - \frac{1}{(1.05)^{30/12}}}{(1.05)^{1/12} - 1}\right)} = \frac{(1,050 - 480.5412)}{(28.18516)}.$$

Since the base for real values is the end of year 1 we can create a nominal payment stream beginning at the end of January using the following relation

TABLE 13.3 Detailed Notes (continued)

$$a_j^n(monthly) = (1+\pi)^{\frac{j-12}{12}} a^r(monthly).$$

The nominal payment stream is as follows.

	Jan	Feb	Mar	Apr	May	Jun	July	Aug	Sep	Oct	Nov	Dec
Nominal Annuity	19.491	19.555	19.619	19.683	19.747	19.812	19.877	19.942	20.007	20.073	20.138	20.204
Adjusted to Dec 31	21.128	21.043	20.957	20.872	20.787	20.703	20.619	20.535	20.452	20.369	20.287	20.204
Partial Sum	21.128	42.171	63.128	84.000	104.788	125.491	146.110	166.646	187.098	207.467	227.753	247.958

If this monthly nominal annuity is used to compute the cost of the breeding animal then nominal interest at an annual rate of 9.2% should be charged. Alternatively, one can compute a real annuity with one payment at the end of the year. Because the cow is held 2.5 years we can compute a fractional annuity as follows.

$$a^r(annual) = \frac{\left(1,050 - \frac{542.88}{(1.05)^{2.5}}\right)}{\left(\frac{1-\frac{1}{(1.05)^{2.5}}}{(.05)}\right)} = \frac{\left(1,050 - 480.5412\right)}{(2.296597)} = \$247.9576.$$

The fractional payment made at the end of 30 months is computed using equation 2B.26 and is given by

$$\begin{aligned} a^r(fractional) &= a\left(\frac{(1+r)^{frac(n)}-1}{r}\right) \\ &= a\left(\frac{(1.05)^{.5}-1}{.05}\right) \\ &= (247.9576)(0.49390) = 122.466. \end{aligned}$$

[n] Capital recovery is based on the difference between the beginning value of the various pieces of equipment and their real salvage value at the end of their useful life. This salvage value is discounted back to the present at a real interest rate of 5% and then subtracted from the initial value to obtain a net present cost of the equipment. This is then converted to a real annual annuity following the

procedures outlined in Chapter 2 and equation 6.7. The manure equipment has a useful life of 12 years and values as in Schedule 14.7.

TABLE 13.3 Detailed Notes (continued)

$$CSC_{manure} = \frac{\left(PP - \frac{SV}{(1+r)^n}\right)}{\left(\frac{1-(1+r)^{-n}}{r}\right)} = \frac{\left(37,073 - \frac{5,272}{(1.05)^{12}}\right)}{\left(\frac{1-(1.05)^{-12}}{.05}\right)} = 3,851.56.$$

Because this is beginning-of-year value it is multiplied by (1.04) to obtain a year-end value of \$4,005.62 [(3,851.56)(1.04)].

The feed handling equipment has a useful life of 15 years and values as in Schedule 14.7.

$$CSC_{feed} = \frac{\left(24,846 - \frac{2,624}{(1.05)^{15}}\right)}{\left(\frac{1-(1.05)^{-15}}{.05}\right)} = 2,272.12.$$

Because this is beginning-of-year value it is multiplied by (1.04) to obtain a year-end value of \$2,363.00 [(2,272.12)(1.04)].

The milking equipment has a useful life of 15 years and values as in Schedule 14.7.

$$CSC_{milking} = \frac{\left(27,675 - \frac{2,922}{(1.05)^{15}}\right)}{\left(\frac{1-(1.05)^{-15}}{.05}\right)} = 2,530.83.$$

Because this is beginning-of-year value it is multiplied by (1.04) to obtain a year-end value of \$2,632.06 [(2,272.12)(1.04)]

The following table summarizes the results.

		Cows	
	Livestock	Percent	Annual
Manure Equipment	\$4,005.62	80	\$3,204.50

Feed Handling Equipment	2,363.00	80	1,890.40
Milking Equipment	2,632.06	100	2,632.06
Annual Total	$10,909.36		$7,720.96
Capital Recovery/Cow			$86.82

TABLE 13.3 Detailed Notes (continued)

[o] The buildings for livestock have an estimated market value of $87,000 (Schedule 14.6). The opportunity cost of this capital is valued at a 5% real rate and a 9.2% nominal rate. The estimated life of each item is given in Schedule 14.6. Equation 6.7 is used to compute capital recovery. Eighty percent of the opportunity cost is allocated to the dairy cows. The data and computations are presented in the following table.

	Manure Pit	**Harvestor 1**	**Heifer Barn**	**Harvestor 2**	**Dairy Barn**	**Stave Silo 1**	**Stave Silo 2**	**Old Barn**	**Hay Shed**	**Total**
	Value	Value	Value							
Vo	2,000.00	8,000.00	5,000.00	20,000.00	40,000.00	5,000.00	1,000.00	3,000.00	3,000.00	87,000.00
Vn	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
n	10	20	20	20	15	20	10	10	20	
Real interest rate	0.0500	0.0500	0.0500	0.0500	0.0500	0.0500	0.0500	0.0500	0.0500	
Inflation rate	0.0400	0.0400	0.0400	0.0400	0.0400	0.0400	0.0400	0.0400	0.0400	
Nominal interest rate	0.0920	0.0920	0.0920	0.0920	0.0920	0.0920	0.0920	0.0920	0.0920	
$V_n/((1+r)^n)$	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	
$V_0-(V_n/((1+r)^n))$	2,000.00	8,000.00	5,000.00	20,000.00	40,000.00	5,000.00	1,000.00	3,000.00	3,000.00	87,000.00
US0(n,r)	7.72173493	12.462210	12.4622103	12.462210	10.379658	12.462210	7.72173493	7.721735	12.46221	95.856
Real annuity	259.0091	641.9407	401.2129	1,604.8517	3,853.6915	401.2129	129.5046	388.5137	240.7278	7,920.665
Inflation adjusted annuity	269.3695	667.6183	417.2615	1,669.0458	4,007.8392	417.2615	134.6848	404.0543	250.3569	8,237.492
% for cows	80	80	80	80	80	80	80	80	80	
Annuity for cows	215.4956	534.0947	333.8092	1,335.2367	3,206.2713	333.8092	107.7478	323.2434	200.2855	6,589.993

Total Annual Cost	6,589.993
Number of Cows	89
Cost per Cow	74.0449

TABLE 13.3 Detailed Notes (continued)

[p] Taxes and insurance are calculated from the data in Schedule 14.8. Approximately 12% of the real estate tax and 65% of the farm insurance is allocated to the dairy cows. These expenses are adjusted forward for inflation so that 1992 values are 4% higher. Real estate taxes for this dairy herd are [(0.12)(3,244)(1.04)] or $404.85. Insurance is [(0.65)(880)(1.04)] or $594.88. The costs per cow (assuming 89 cows in the herd) are $4.55 and $6.68, respectively, for a total of $11.23.

[q] General farm overhead includes the dairy cows' share (65%) of overhead expenses (Schedule 14.8) adjusted for inflation. The total overhead is $13,094 (1,194+3,500+7,165+1,235). Multiplying by 0.65, adjusting for inflation, and dividing by the number of cows gives a total of $\left[\frac{(13{,}094)(0.65)(1.04)}{89}\right] = \$99.46$ per cow.

Table 13.3R A Sample Detailed CAR Summary for a Dairy Budget (Real values)
Real 1992 Projected Costs and Returns for Milk Production Per Cow, Detailed
(Uses Capital Recovery to Account for Cost of Replacement Heifers)
Ben & Bev Dairyman Farm, Upper Midwest, USA (See Chapter 14 for a complete description of the farm)
Prepared by John Q. Taskforce, Department of Agricultural Economics, Anonymous State University, March 1992

	Item	Units	Quantity	Price	Value
	Gross Value Of Production				
1	Milk(a)	cwt	216.00	12.50	2,699.78
2	Cull Cows (b)	cwt	4.68	46.40	0.00
3	Bull Calves (c)	hd	0.42	125.00	51.92
4	Heifer Calves (c)	hd	0.42	150.00	62.31
5	Interest On Receipts to December(d)			0.050	63.68
6	Total (e)				2,877.68
	Operating Costs				
7	Replacement Heifer (f)	hd	0.40	1050.00	0.00
8	Corn (g)	bu	135.00	2.10	283.50
9	Protein, Vit. & Min. (g)	cwt	12.72	15.23	193.73
10	Alfalfa Hay (g)	ton	2.19	80.00	175.20
11	Alfalfa Haylage (g)	ton	2.37	75.00	177.75
12	Corn Silage (g)	ton	3.96	16.70	66.13
13	Marketing (milk) (h)	cwt	216.00	0.49	105.20
14	Breeding (i)	cow	1.00	47.65	47.65
15	Veterinary & Medicine (i)	cow	1.00	65.69	65.69
16	Supplies (i)	cow	1.00	158.82	158.82
17	Fuel, Oil & Utilities (j)				27.06
18	Repairs (k)				307.61
19	Bedding				
20	Interest On Oper. Costs To Dec.(d)			0.050	36.53
21	Total Operating Costs (e)				1,644.87
	Allocated Overhead				
22	Hired Labor (l)				262.97
23	Opportunity Cost Of Unpaid Labor(l)				247.85
24	Opportunity Interest on Labor				11.60
25	Capital Recovery Of Livestock Investment(m)				247.96
26	Capital Recovery Of Mach & Eq Investment(n)				86.82
27	Capital Recovery of Bldg Investment (o)				74.04
28	Taxes & Insurance (p)				11.23
29	General Farm Overhead (q)				99.46
30	Total Allocated Overhead (e)				1,041.93
31	Total Costs Listed (e)				2,686.80
32	Value Of Prod. Less Total Oper. Costs (e)				1,232.81
33	Value Of Prod. Less Total Costs Listed (e)				190.88

TABLE 13.3R Real 1992 Projected Costs and Returns for Milk Production Per Cow, Detailed Notes (Table 13A.1R contains cost and revenue data by month for the dairy enterprise.)

[a] Quantity sold is the total for the year; sales each month are 18 cwt. Price per cwt for milk is based on a non-seasonally adjusted real average price at the end of the year of $12.50. This was adjusted using the seasonal index below to account for typical seasonality in milk prices. Real interest on this revenue from the month of sale to December 31 is recorded on line 5. It is assumed that revenue from milk is received at the end of the month. Because quantities per month are constant, the average real price for the year multiplied by the total quantity gives the actual total revenue (expenditure).

	Jan	Feb	Mar	Apr	May	Jun	July	Aug	Sep	Oct	Nov	Dec	Average
Seasonal Index	103.0	101.8	100.0	98.4	96.8	95.7	96.4	97.7	100.3	102.7	103.8	103.3	100.00
1992 Real (seas. adj.)	12.875	12.725	12.500	12.300	12.100	11.963	12.050	12.213	12.538	12.838	12.975	12.913	12.500
1992 Nominal	12.420	12.316	12.138	11.983	11.826	11.730	11.855	12.054	12.415	12.754	12.933	12.913	12.278

[b] Dairy cows are assumed to be replaced every 2.5 years giving a replacement rate of .40. It is assumed that 1% of the cows die each year (2.5% over the 30 month period) and thus are not available to be sold. This gives an effective cull rate of .39 [0.40 - 0.01 or (0.975)(0.40)]. The average weight of the .39 cows culled per year is 1,200 pounds. This gives per cow culled sales of 468 pounds [(.39)(1,200)]. Price per cwt for cull cows is based on a non-seasonally adjusted real average price at the end of the year of $46.40. The seasonally adjusted price is $42.8736 which is both a real and nominal value for December 31.

Because the estimate in Table 13.3R uses the capital recovery method to value investment in the breeding herd, no income from cull sales is included in the estimates. The value of the cull animal is included as a negative cost in computing the cost of a breeding herd replacement in line 25 of Table 13.3R.

[c] See note [c] in Table 13.3. The prices for calves reflect the market in the area for 3-day-old calves and is assumed to have a constant real value during the year. This is projected to be $125 for bull calves and $150 for heifer calves on December 31, 1992. As with the cull cows, the calf sales are assumed to be equally spaced during the year.

[d] All receipts and expenses are assumed to occur on the last day of the month. Interest is compounded at the monthly rate of .0040741 [$(1.050)^{\frac{1}{12}} - 1$], (equivalent to an annual rate of .05) until the last day of December.

[e] Individual values may not sum to totals due to rounding.

[f] Dairy cows are assumed to be replaced every 2.5 years giving a replacement rate of .40. The cull rate of .39 allows for some death loss over the life of the cow. A real price of $1,050 per replacement

TABLE 13.3R Detailed Notes (continued)

as of December 1992 is assumed. Because this estimate uses the capital recovery method for valuing the investment in the herd, no replacement cost is included on line 7 of the report. The value of the replacement is included in computing the cost of a breeding herd replacement on line 25 of Table 13.3R.

[g] See note [g] in Table 13.3. The prices in Table 13.3R are the real prices for the year and reflect net market prices the farm would receive. The prices are not seasonally adjusted.

[h] See note [h] in Table 13.3. The real average price for the year is .4870 which rounds to .49 in Table 13.3R.

[i] See note [i] in Table 13.3. The computed real payment is per month $3.97048. Multiplied by 12 months gives an annual payment of $47.65 for breeding. Veterinary and medicine in 1991 were $62.04, while supplies were $150, giving 1992 total nominal expenses of $64.52 and $156. The real monthly payments are $5.474 and $13.235, giving annual expenditures of $65.69 and $158.82 respectively.

[j] See note [j] in Table 13.3. The real expenditure per month is $2.2554 giving an annual total of $27.06.

[k] See note [k] in Table 13.3. The real monthly cost of $25.634 leads to an annual cost of $307.61.

[l] See note [l] in Table 13.3. The labor costs are charged interest at a real rate.

[m] See note [l] in Table 13.3. The capital costs are in real terms at the end of the year.

[n] See note [n] in Table 13.3. The capital costs are in real terms at the end of the year.

[o] See note [o] in Table 13.3. The building costs are in real terms at the end of the year.

[p] See note [p] in Table 13.3. Taxes and Insurance are in real terms at the end of the year.

[q] See note [q] in Table 13.3. General Farm Overhead is in real terms at the end of the year.

TABLE 13.4 Whole-Farm Overhead Cost Items

Overhead Item	Whole Farm	Enterprise 1	Enterprise 2	Enterprise n
Accounting/legal fees				
Advertising				
Computer & related office equipment (annualized costs)				
Education costs within year				
Farm office (maintenance, insurance, capital recovery, etc.)				
Farm organization dues/meetings				
Farm shop (portions could be included in repair cost estimates)				
General use vehicles (whole-farm share)				
Maintenance of general farm facilities—roads, boundary fences, water system, etc.				
Property/casualty insurance				
Publications				
Umbrella liability insurance				
Utilities/phone				
TOTAL	Total Farm	Tot. Ent. 1	Tot. Ent. 2	Tot. Ent. n

Notes:
(1) Each line in this worksheet is allocated separately.
(2) The total for each enterprise is transferred as a single line item input into the respective enterprises.

TABLE 13.5 Expense Items Check List for Crop CAR Estimates[1]

Seed, seed stock, plants, seedlings, etc.
Fertilizer consumed (by blend or by total N, P, K, etc.)
Chemicals (by type; application costs must be separable)
- -- Herbicide
- -- Insecticide
- -- Fungicide
- -- Growth regulators
- -- Harvest aids

Custom services (by type)
Machinery
- -- Fuel and lube
- -- Repairs

Irrigation
- -- Water (consider system efficiency)
- -- Water district charges, taxes, and other expenses
- -- Fuel and lube
- -- Repairs

Utilities (enterprise specific)
Labor (see Chapter 8 for labor recommendations)
Miscellaneous crop-specific supplies
Crop insurance (offset with indemnity payment if applicable)
Costs of accessing market
Checkoff/assessment (involuntary)
Shipping/transportation
Storage/processing (if reflected in product sales)
Interest on operating capital
Land rent (see Chapter 7 on land costs)
Crop establishment costs (see Chapter 10 multiyear enterprise section)
Capital recovery on durable machinery and equipment (See Chapter 6)
Allocated farm overhead
Tax and insurance on machinery and equipment for the enterprise

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[1]Consult various sections of the Report for recommendations on calculating costs for different items.

TABLE 13.6 Expense Items Check List for Livestock CAR Estimates[1]

Feed, minerals, and feed additives (by type)
Forage (by type)
Animal health/performance
- -- Vet services and medicines
- -- Pest control/chemicals
- -- Expendable health equipment and supplies

Breeding costs
- -- Bull, boar, ram, stallion fee (or maintenance cost)
- -- AI charge including semen
- -- Estrus synchronization
- -- Pregnancy checking

Machinery and equipment, including buildings
- -- Fuel/lube or utilities specific to the enterprise
- -- Repairs

Labor
Grazing fees, land rental, pasture maintenance
Livestock-specific supplies
Marketing costs (e.g., commissions, feed, bedding)
Hauling/transportation (if not reflected in prices used)
Checkoffs/assessments (involuntary)
Livestock purchased for resale
Interest on operating capital
Access to market
Capital recovery for machinery/equipment/buildings
Taxes and insurance on machinery/equipment/buildings
Allocated farm overhead

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[1] Consult Report sections for recommendations concerning calculating costs for different items.

APPENDIX 13A

SUPPLEMENTARY DATA TABLES FOR CHAPTER 13

This appendix contains data tables that support the CAR estimates in Tables 13.2 and 13.3. It also contains alternate estimates of milk production using the market value, historic cost, and current cost methods of accounting for the cost of replacement livestock as compared to the capital recovery method used in Table 13.3. Table 13A.1 contains monthly price, quantity, return, and cost data for the dairy enterprise discussed in Chapter 13. Table 13A.2 contains a CAR estimate using the market value methods for valuing replacement animals while Tables 13A.3A and 13A.3B illustrate the historic cost method of valuing replacement animals. The current value method is used in Table 13A.4. Table 13A.5A presents estimates of the cost of raising a dairy heifer from birth to one year of age in current dollars while Table 13A.5B shows estimates of the cost of raising a dairy heifer from one year of age to freshening. Tables 13A.6A and 13A.6B are the detailed monthly tables that support Tables 13A.5A and 13A.5B. Table 13A.7 gives the current combined costs of raising one heifer from birth to age one year and from one year to freshening. Whereas Tables 13A.5AB and 13A.6AB consider these costs of assuming the birth of a one heifer in January with freshening at two years of age in a subsequent January, Table 13A.7 assumes that heifer births and growth occur continuously over time so 1/12 of a heifer is born each month, is weaned each month, is bred each month, and so forth. Thus, whereas the data in Tables 13A.5AB and 13A.6AB estimate costs based on a seasonal pattern of expenses consistent with the growth pattern of a heifer, Table 13A.7 assumes equal expenditures in each and every month. Table 13A.8 is a listing of monthly and annual average prices used in the estimation.

Table 13A.1 Income & Expenses Per Month For 1992 Projected Costs & Returns For Milk Production Per Cow														
ITEM	**UNIT**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**ANNUAL**
----------------------	-------	------------	------------	------------	------------	------------	------------	------------	------------	------------	------------	------------	------------	------------
		1	2	3	4	5	6	7	8	9	10	11	12	
Quantity Sold														
Milk	cwt	18	18	18	18	18	18	18	18	18	18	18	18	216
Cull Cows	cwt	0.39	0.39	0.39	0.39	0.39	0.39	0.39	0.39	0.39	0.39	0.39	0.39	4.68
Bull Calves	HD	0.034615	0.034615	0.034615	0.034615	0.034615	0.034615	0.034615	0.034615	0.034615	0.034615	0.034615	0.034615	0.4153846
Heifer Calves	HD	0.034615	0.034615	0.034615	0.034615	0.034615	0.034615	0.034615	0.034615	0.034615	0.034615	0.034615	0.034615	0.4153846
Sale Price														
Milk	$/cwt	12.42	12.32	12.14	11.98	11.83	11.73	11.85	12.05	12.42	12.75	12.93	12.91	12.277969
Cull Cows	$/cwt	42.97	46.30	47.53	47.15	47.16	46.18	45.88	46.35	46.18	45.08	43.06	42.87	45.55924
Bull Calves	$/HD	120.59	120.98	121.38	121.77	122.17	122.57	122.97	123.38	123.78	124.19	124.59	125.00	122.78087
Heifer Calves	$/HD	144.70	145.18	145.65	146.13	146.61	147.09	147.57	148.05	148.54	149.02	149.51	150.00	147.33704
Value Of Production														
Milk	$	223.566	221.6848	218.4779	215.6861	212.8736	211.1435	213.3842	216.9698	223.473	229.5694	232.7879	232.425	2652.0413
Cull Cows	$	16.75868	18.05705	18.53788	18.38702	18.39415	18.01076	17.89169	18.07529	18.00903	17.58258	16.7924	16.7207	213.21724
Bull Calves	$	4.174123	4.187788	4.201498	4.215253	4.229052	4.242897	4.256787	4.270723	4.284704	4.298731	4.312804	4.326923	51.001285
Heifer Calves	$	5.008948	5.025346	5.041798	5.058303	5.074863	5.091477	5.108145	5.124867	5.141645	5.158477	5.175365	5.192308	61.201542
Total Revenue		249.5078	248.9549	246.2591	243.3466	240.5716	238.4887	240.6409	244.4407	250.9084	256.6092	259.0685	258.6649	2977.4614
Annual Nominal Int Rate	Decimal	0.0920	0.0920	0.0920	0.0920	0.0920	0.0920	0.0920	0.0920	0.0920	0.0920	0.0920	0.0920	
Monthly Compound Int Rate	Decimal	0.007361	0.007361	0.007361	0.007361	0.007361	0.007361	0.007361	0.007361	0.007361	0.007361	0.007361	0.007361	
Valuation Month(Dec=12, etc)	Integer	12	12	12	12	12	12	12	12	12	12	12	12	
Valuation Month-Current Month	Integer	11	10	9	8	7	6	5	4	3	2	1	0	
Compound Int To Valuation Month (Milk)	$	18.78409	16.86997	14.90793	13.03378	11.21427	9.498933	7.970303	6.459522	4.971507	3.392253	1.713599	0	108.81616
Compound Int To Valuation Month (Culls)	$	1.40807	1.374122	1.26494	1.111117	0.969011	0.810269	0.668288	0.538129	0.400639	0.259811	0.123612	0	8.928008
Compound Int To Valuation Month (Bulls)	$	0.350711	0.318686	0.286691	0.254725	0.222788	0.19088	0.158999	0.127146	0.09532	0.063521	0.031747	0	2.1012143
Compound Int To Valuation Month (Heifers)	$	0.420853	0.382423	0.344029	0.30567	0.267346	0.229056	0.190799	0.152575	0.114384	0.076225	0.038097	0	2.5214571
Compound Int To Valuation Month (Total)	$	20.96372	18.9452	16.80359	14.70529	12.67341	10.72914	8.988389	7.277373	5.58185	3.791809	1.907055	0	122.36684

Table 13A.1: Income & Expenses Per Month For 1992 Projected Costs & Returns For Milk Production Per Cow (cont)														
ITEM	**UNIT**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**ANNUAL**
Quantity Purchased														
Replacement Heifer	HD	0.033333	0.033333	0.033333	0.033333	0.033333	0.033333	0.033333	0.033333	0.033333	0.033333	0.033333	0.033333	0.4
Corn	Bu	11.25	11.25	11.25	11.25	11.25	11.25	11.25	11.25	11.25	11.25	11.25	11.25	135
Protein, Vit. & Min	cwt	1.06	1.06	1.06	1.06	1.06	1.06	1.06	1.06	1.06	1.06	1.06	1.06	12.72
Alfalfa Hay	ton	0.1825	0.1825	0.1825	0.1825	0.1825	0.1825	0.1825	0.1825	0.1825	0.1825	0.1825	0.1825	2.19
Alfalfa Haylage	ton	0.1975	0.1975	0.1975	0.1975	0.1975	0.1975	0.1975	0.1975	0.1975	0.1975	0.1975	0.1975	2.37
Corn Silage	ton	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33	3.96
Marketing	cwt	18	18	18	18	18	18	18	18	18	18	18	18	216
Purchase Price														
Replacement Heifer	$/HD	1012.92	1016.24	1019.56	1022.90	1026.25	1029.61	1032.98	1036.36	1039.75	1043.16	1046.57	1050.00	1031.3593
Corn	$/Bu	2.03	2.03	2.04	2.05	2.05	2.06	2.07	2.07	2.08	2.09	2.09	2.10	2.063
Protein, Vit. & Min	$/cwt	14.69	14.74	14.79	14.84	14.89	14.93	14.98	15.03	15.08	15.13	15.18	15.23	14.960
Alfalfa Hay	$/Ton	77.17	77.43	77.68	77.94	78.19	78.45	78.70	78.96	79.22	79.48	79.74	80.00	78.580
Alfalfa Haylage	$/Ton	72.35	72.59	72.83	73.06	73.30	73.54	73.78	74.03	74.27	74.51	74.76	75.00	73.669
Corn Silage	$/Ton	16.11	16.16	16.22	16.27	16.32	16.38	16.43	16.48	16.54	16.59	16.65	16.70	16.404
Marketing	$/cwt	0.47	0.47	0.47	0.47	0.48	0.48	0.48	0.48	0.48	0.48	0.49	0.49	0.478
Operating Costs														
Replacement Heifer	$	33.76402	33.87455	33.98545	34.09671	34.20833	34.32032	34.43268	34.5454	34.6585	34.77196	34.88579	35	412.54372
Corn	$	22.79071	22.86532	22.94018	23.01528	23.09063	23.16622	23.24206	23.31815	23.39448	23.47107	23.54791	23.625	278.46701
Protein, Vit. & Min	$	15.5737	15.62469	15.67584	15.72716	15.77864	15.8303	15.88212	15.93412	15.98628	16.03862	16.09112	16.1438	190.28638
Alfalfa Hay	$	14.08442	14.13053	14.17679	14.2232	14.26976	14.31648	14.36335	14.41037	14.45754	14.50487	14.55236	14.6	172.08967
Alfalfa Haylage	$	14.28942	14.3362	14.38313	14.43022	14.47746	14.52485	14.5724	14.62011	14.66797	14.71599	14.76417	14.8125	174.5944
Corn Silage	$	5.316386	5.333791	5.351252	5.368771	5.386347	5.40398	5.421671	5.43942	5.457228	5.475093	5.493017	5.511	64.957956
Marketing	$	8.457248	8.484935	8.512713	8.540581	8.568541	8.596592	8.624735	8.65297	8.681298	8.709718	8.738231	8.766838	103.3344
Breeding	$	3.830276	3.842815	3.855395	3.868017	3.88068	3.893384	3.90613	3.918918	3.931747	3.944619	3.957532	3.970488	46.8
Veterinary & Medicine	$	5.280673	5.297961	5.315305	5.332706	5.350164	5.367679	5.385251	5.402881	5.420569	5.438314	5.456118	5.47398	64.5216
Supplies	$	12.76759	12.80938	12.85132	12.89339	12.9356	12.97795	13.02043	13.06306	13.10582	13.14873	13.19177	13.23496	156
Fuel & Oil	$	2.17575	2.182872	2.190019	2.197188	2.204381	2.211598	2.218838	2.226102	2.233389	2.240701	2.248036	2.255396	26.58427
Bedding	$													
Repairs (nominal $)	$	24.7291	24.8100	24.8912	24.9727	25.0545	25.1365	25.2188	25.3013	25.3842	25.4673	25.5507	25.6343	302.15052
Total (exclude dairy heifer)	$	129.2952	129.7185	130.1432	130.5692	130.9967	131.4255	131.8558	132.2874	132.7205	133.155	133.5909	134.0283	1579.7862
Total Operating Costs	$	163.0592	163.5931	164.1286	164.6659	165.205	165.7458	166.2885	166.8328	167.379	167.927	168.4767	169.0283	1992.3299
Annual Nominal Int Rate	Decimal	0.0920	0.0920	0.0920	0.0920	0.0920	0.0920	0.0920	0.0920	0.0920	0.0920	0.0920	0.0920	
Monthly Compound Nominal Int Rate	Decimal	0.007361	0.007361	0.007361	0.007361	0.007361	0.007361	0.007361	0.007361	0.007361	0.007361	0.007361	0.007361	
Valuation Month(Dec=12, etc)	Integer	12	12	12	12	12	12	12	12	12	12	12	12	
Valuation Month-Current Month	Integer	11	10	9	8	7	6	5	4	3	2	1	0	
Compound Int To Valuation Month (no heifers	$	10.86342	9.871439	8.880375	7.890219	6.900958	5.912576	4.925061	3.938399	2.952575	1.967577	0.98339	0	65.085995
Compound Int To Valuation Month (inc heifers	$	13.70029	12.44926	11.19939	9.950663	8.703067	7.45658	6.211187	4.966868	3.723608	2.481388	1.240191	0	82.082483
Allocated Overhead														
Hired Labor	$	21.14	21.21	21.28	21.35	21.42	21.49	21.56	21.63	21.70	21.77	21.84	21.91	258.300
Opportunity Cost Of Unpaid Labor	$	19.92	19.99	20.06	20.12	20.19	20.25	20.32	20.39	20.45	20.52	20.59	20.65	243.448
Compound Int (Labor) To Valuation Month	$	3.45	3.14	2.82	2.51	2.19	1.88	1.56	1.25	0.94	0.62	0.31	0.00	20.672
Capital Recovery Of Livestock Inv		21.12833	21.0426	20.95722	20.87218	20.78749	20.70315	20.61914	20.53548	20.45215	20.36917	20.28652	20.2042	247.95763
Capital Recovery Of Machinery Inv														86.82
Capital Recovery of Bldg Inv														74.0449
Taxes & Insurance														11.23
General Farm Overhead														99.46
Total Allocated Overhead														1041.931
Total Costs (Cap Recovery)														3099.347
Total Costs (Market Value)														#VALUE!

Table 13A.2 A Sample Detailed CAR Summary for a Dairy Budget
1992 Projected Costs and Returns for Milk Production Per Cow, Detailed
(Market value method used to account for cost of replacement heifers)
Ben & Bev Dairyman Farm, Upper Midwest, USA (See Chapter 14 for a complete description of the farm)
Prepared by John Q. Taskforce, Department of Agricultural Economics, Anonymous State University, March 1992

	Item	Units	Quantity	Price	Value
	Gross Value Of Production				
1	Milk (a)	cwt	216.00	12.28	2,652.04
2	Cull Cows (b)	cwt	4.68	45.56	213.22
3	Bull Calves (c)	hd	0.42	122.78	51.00
4	Heifer Calves (c)	hd	0.42	147.34	61.20
5	Interest On Receipts to December (d)			0.092	122.37
6	Total (e)				3,099.83
	Operating Costs				
7	Replacement Heifer (f)	hd	0.40	1031.36	412.54
8	Corn (g)	bu	135.00	2.06	278.47
9	Protein, Vit., & Min. (g)	cwt	12.72	14.96	190.29
10	Alfalfa Hay (g)	ton	2.19	78.58	172.09
11	Alfalfa Haylage (g)	ton	2.37	73.67	174.59
12	Corn Silage (g)	ton	3.96	16.40	64.96
13	Marketing (milk) (h)	cwt	216.00	0.48	103.33
14	Breeding (i)	cow	1.00	46.80	46.80
15	Veterinary & Medicine (i)	cow	1.00	64.52	64.52
16	Supplies (i)	cow	1.00	156.00	156.00
17	Fuel, Oil, & Utilities (j)				26.58
18	Repairs (k)				302.15
19	Bedding				
20	Interest On Oper. Costs To Dec. (d)			0.092	82.08
21	Total Operating Costs (e)				2,074.41
	Allocated Overhead				
22	Hired Labor (l)				258.30
23	Opportunity Cost Of Unpaid Labor(l)				243.45
24	Opportunity Interest on Labor				20.67
25	Opportunity Interest On Livestock Investment (m)				44.89
26	Capital Recovery of Bldg Investment (n)				86.82
27	Opportunity Cost Of Bldg Investment (o)				74.04
28	Taxes & Insurance (p)				11.23
29	General Farm Overhead (q)				99.46
30	Total Allocated Overhead (e)				838.87
31	Total Costs Listed (e)				2,913.28
32	Value Of Prod. Less Total Oper. Costs (e)				1,025.42
33	Value Of Prod. Less Total Costs Listed (e)				186.55

TABLE 13A.2 1992 Projected Costs and Returns for Milk Production Per Cow (Market Value Method), Detailed Notes

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[a] See notes for Table 13.3.

[b] The average weight of the .39 cows culled per year is 1,200 pounds. This gives per cow culled sales of 468 pounds [(.39)(1,200)]. Price per cwt for cull cows is based on a nonseasonally adjusted real average price at the end of the year of $46.40. This was adjusted using the seasonal index below to account for typical seasonality in cattle prices and then adjusted to a nominal basis assuming a 4% annual rate of inflation. The nominal price at the end of December (the base period) is $46.40 while the average nominal price over the 12 months of the year is $45.56. This gives revenue of $213.22 [(4.68)(45.46)]. Nominal interest on this revenue from the month of sale to December 31 is recorded on line 5 of the Table. It is assumed that revenue from cull cow sales is received at the end of the month with an equal quantity sold per month.

	Jan	Feb	Mar	Apr	May	Jun	July	Aug	Sep	Oct	Nov	Dec	Average
Seasonal Index	96.00	103.10	105.50	104.30	104.00	101.50	100.50	101.20	100.50	97.80	93.10	92.40	99.992
1992 Real (seas. adj.)	44.544	47.838	48.952	48.395	48.256	47.096	46.632	46.956	46.632	45.379	43.198	42.873	46.396
1992 Nominal	42.971	46.300	47.533	47.146	47.164	46.181	45.876	46.346	46.177	45.083	43.057	42.873	45.559

[c] See notes for Table 13.3.

[d] See notes for Table 13.3. Interest on revenue in Table 13A.2 is larger than in Table 13.3 due to the inclusion of cull cow sales as revenue. Interest on operating expenses is also larger due to the inclusion of the heifer purchase as an operating expense.

[e] Individual values may not add to totals due to rounding.

[f] Dairy cows are assumed to be replaced every 2.5 years giving a replacement rate of .40. The cull rate of .39 allows for 1% death loss each year and 2.5% death loss over 2.5 years. A real price for replacement heifers of $1,050 as of December 1992 is assumed. This gives a nominal price at the beginning of January 1992 of $1,009.6155. This is adjusted to reflect 4% inflation during the year with a nominal average for the 12 months of $1,031.359. The annual payment is then $412.54 [(.40)(1,031.36)].

[g] See notes for Table 13.3.

[h] See notes for Table 13.3.

[i] See notes for Table 13.3.

[j] See notes for Table 13.3.

[k] See notes for Table 13.3.

TABLE 13A.2 Detailed Notes (continued)

[l] See notes for Table 13.3.

[m] Because we are using the market value method, there is no capital recovery and cost is based on the opportunity interest associated with the investment in the cow since cull sales and heifer purchases are accounted for in other sections of the estimate. The traditional method of computing opportunity interest based on equations 6.5 and 6.6 (also equations 10.3 and 10.4) is used to obtain a value for investment. Specifically, we compute real opportunity interest on an average year-end value of V_0 given by $\left(\frac{V_0 + V_n + D}{2}\right)$ where D is straight-line depreciation computed as $D = \frac{V_0 - V_n}{n}$ and V_0

= Value of the cow at the beginning of the first year in real terms
V_n = Real value of the cow at the end of her useful life (period n)
n = useful life in years.

This value is multiplied by the real interest rate (r) to obtain opportunity interest cost (OC) as

$$OC = \left(\frac{V_0 + V_n + D}{2}\right)(r).$$

Because the herd has a rolling inventory of cows, some older and some younger, this "average" value is used as an approximation of the value of the representative cow at the beginning of the year. The real value of a heifer is $1,050. The real value of a cull animal (assuming 1% death loss per year or 2.5 % over 2.5 years) is obtained by multiplying the net sales weight [(12 cwt)(.975)] by the market price for cull cows ($46.40 per cwt) to obtain $542.88. The assumed productive life of the cow is 30 months (2.5 years) so D is given by $D = \frac{1,050 - 542.88}{2.5} = \$202.848$. We compute an average inventory value in real terms as $\text{Average } V_0^r = \left(\frac{1,050 + 542.88 + 202.848}{2}\right) = \$897.864$.

Opportunity interest is computed directly then as [(897.864)(0.05)] = $44.8932. We can also convert this average value to beginning-of-year nominal terms by dividing it by $(1 + \pi)$ to obtain $863.33 $[(897.864)(1.04)^{-1}]$. Opportunity interest is computed as [(863.33)(0.05)] = $43.1665. Adjusting this to end of the year prices will give $44.8932 [(43.1665)(1.04)].

[n]-[q] See notes for Table 13.3.

Table 13A.3A A Sample Detailed CAR Summary for a Dairy Budget
1992 Projected Costs and Returns for Milk Production Per Cow, Detailed
(Historic Cost Method used to Account for Cost of Replacement Heifers)
Ben & Bev Dairyman Farm, Upper Midwest, USA (See Chapter 14 for a complete description of the farm)
Prepared by John Q. Taskforce, Department of Agricultural Economics, Anonymous State University, March 1992

	Item	Units	Quantity	Price	Value
	Gross Value Of Production				
1	Milk (a)	cwt	216.00	12.28	2,652.04
2	Cull Cows (b)	cwt	4.68	45.56	213.22
3	Bull Calves (c)	hd	0.42	122.78	51.00
4	Heifer Calves (c)	hd	0.42	147.34	61.20
5	Interest On Receipts to December (d)			0.092	122.37
6	Total (e)				3,099.83
	Operating Costs				
7	Replacement Heifer (f)	hd	0.40	1140.10	456.04
8	Corn (g)	bu	135.00	2.06	278.47
9	Protein, Vit., & Min. (g)	cwt	12.72	14.96	190.29
10	Alfalfa Hay (g)	ton	2.19	78.58	172.09
11	Alfalfa Haylage (g)	ton	2.37	73.67	174.59
12	Corn Silage (g)	ton	3.96	16.40	64.96
13	Marketing (milk) (h)	cwt	216.00	0.48	103.33
14	Breeding (i)	cow	1.00	46.80	46.80
15	Veterinary & Medicine (i)	cow	1.00	64.52	64.52
16	Supplies (i)	cow	1.00	156.00	156.00
17	Fuel, Oil, & Utilities (j)				26.58
18	Repairs (k)				302.15
19	Bedding				
20	Interest On Oper. Costs To Dec. (d)			0.092	83.87
21	Total Operating Costs (e)				2,119.70
	Allocated Overhead				
22	Hired Labor (l)				258.30
23	Opportunity Cost Of Unpaid Labor(l)				243.45
24	Opportunity Interest on Labor				20.67
25	Opportunity Interest On Livestock Investment (m)				48.77
26	Capital Recovery of Bldg Investment (n)				86.82
27	Opportunity Cost Of Bldg Investment (o)				74.04
28	Taxes & Insurance (p)				11.23
29	General Farm Overhead (q)				99.46
30	Total Allocated Overhead (e)				842.74
31	Total Costs Listed (e)				2,962.44
32	Value Of Prod. Less Total Oper. Costs (e)				980.13
33	Value Of Prod. Less Total Costs Listed (e)				137.38

TABLE 13A.3A 1992 Projected Costs and Returns for Milk Production Per Cow (Historic Value Method), Detailed Notes

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[a] See notes for Table 13.3.

[b] See notes for Table 13A.2.

[c] See notes for Table 13.3.

[d] See notes for Table 13A.2.

[e] Individual values may not add to totals due to rounding.

[f] Dairy cows are assumed to be replaced every 2.5 years giving a replacement rate of .40. The cull rate of .39 allows for 1% death loss each year and 2.5% death loss over 2.5 years. A real price for replacement heifers is estimated based on the cost of raising a heifer in the herd. These are summarized in Table 13A.5AB. Table 13A.5A gives the costs of raising a heifer from birth to one year of age assuming 1992 prices for all inputs including the heifer calf valued at $150 as of December 1992. The estimates in Table 13A.5A assume the heifer calf is born on January 1, 1991. Table 13A.5B gives the cost of raising the same calf from age 1 year to the point of freshening (2 years) also assuming 1992 prices. We follow the convention that inflation outside the current period is 0%. To have a heifer ready to enter the herd on January 1, 1991, the calf must be born on January 1, 1989. Given this time line, the first year costs will accrue interest from the end of 1990 to the beginning of 1991 at a 5% real rate. The second year costs will already be in end-of-second-year dollars. The first year cost in end-of-1992 dollars is $577.67. The second year cost from Table 13A.5B is $554.16. This gives a total cost in end-of-1992 dollars of $1,160.7135 [(577.67)(1.05) + $554.16]. This gives a beginning-of-year (January 1) value of $1,116.07 [(1,160.71)/(1.04)]. The average nominal price over the year is $1,140.10 as compared to $1,031.36 in the case of a purchased replacement. The annual payment is then $456.04 [(.40)(1,140.10)].

[g] - [l] See notes for Table 13.3.

[m] Because we are using the historic cost method, there is no capital recovery and cost is based on the opportunity interest associated with the investment in the cow since cull sales and heifer purchases are accounted for in other sections of the estimate. The traditional method of computing opportunity interest based on equations 6.5 and 6.6 (also equations 10.3 and 10.4) is used to obtain a value for investment. Specifically, we compute real opportunity interest on an average year-end value of V_0 as in Table 13A.2. The real value of a heifer in end-of-1992 dollars from footnote f is $1,160.71 [(577.67)(1.05) + $554.16]. The real value of a cull animal (assuming 1% death loss per year or 2.5 % over 2.5 years) is $542.88 as before. The assumed productive life of the cow is 30 months (2.5 years) so D is given by $D = \frac{1,160.71 - 542.88}{2.5} = \$247.132$. We compute an average inventory

TABLE 13A.3A Detailed Notes (continued)

value in real terms as $\text{Average } V_0^r = \left(\frac{1,160.71 + 542.88 + 247.132}{2} \right) = \$975.361$. Opportunity interest is computed directly then as [(975.361)(0.05)] = $48.768.

[n] - [q] See notes for Table 13.3.

Table 13A.3B Income & Expenses Per Month For Projected 1992 Costs & Returns For Milk Production Per Cow (Historic Cost Method)

ITEM	UNIT	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	ANNUAL
----------------------	-------	-----------	-----------	-----------	-----------	-----------	-----------	-----------	-----------	-----------	-----------	-----------	-----------	-----------
		1	2	3	4	5	6	7	8	9	10	11	12	
Quantity Sold														
Milk	cwt	18	18	18	18	18	18	18	18	18	18	18	18	216
Cull Cows	cwt	0.39	0.39	0.39	0.39	0.39	0.39	0.39	0.39	0.39	0.39	0.39	0.39	4.68
Bull Calves	HD	0.034615	0.034615	0.034615	0.034615	0.034615	0.034615	0.034615	0.034615	0.034615	0.034615	0.034615	0.034615	0.4153846
Heifer Calves	HD	0.034615	0.034615	0.034615	0.034615	0.034615	0.034615	0.034615	0.034615	0.034615	0.034615	0.034615	0.034615	0.4153846
Sale Price														
Milk	$/cwt	12.42	12.32	12.14	11.98	11.83	11.73	11.85	12.05	12.42	12.75	12.93	12.91	12.277969
Cull Cows	$/cwt	42.97	46.30	47.53	47.15	47.16	46.18	45.88	46.35	46.18	45.08	43.06	42.87	45.55924
Bull Calves	$/HD	120.59	120.98	121.38	121.77	122.17	122.57	122.97	123.38	123.78	124.19	124.59	125.00	122.78087
Heifer Calves	$/HD	144.70	145.18	145.65	146.13	146.61	147.09	147.57	148.05	148.54	149.02	149.51	150.00	147.33704
Value Of Production														
Milk	$	223.566	221.6848	218.4779	215.6861	212.8736	211.1435	213.3842	216.9698	223.473	229.5694	232.7879	232.425	2652.0413
Cull Cows	$	16.75868	18.05705	18.53788	18.38702	18.39415	18.01076	17.89169	18.07529	18.00903	17.58258	16.7924	16.7207	213.21724
Bull Calves	$	4.174123	4.187788	4.201498	4.215253	4.229052	4.242897	4.256787	4.270723	4.284704	4.298731	4.312804	4.326923	51.001285
Heifer Calves	$	5.008948	5.025346	5.041798	5.058303	5.074863	5.091477	5.108145	5.124867	5.141645	5.158477	5.175365	5.192308	61.201542
Total Revenue		249.5078	248.9549	246.2591	243.3466	240.5716	238.4887	240.6409	244.4407	250.9084	256.6092	259.0685	258.6649	2977.4614
Annual Nominal Int Rate	Decimal	0.092	0.092	0.092	0.092	0.092	0.092	0.092	0.092	0.092	0.092	0.092	0.092	
Monthly Compound Int Rate	Decimal	0.007361	0.007361	0.007361	0.007361	0.007361	0.007361	0.007361	0.007361	0.007361	0.007361	0.007361	0.007361	
Valuation Month(Dec=12, etc)	Integer	12	12	12	12	12	12	12	12	12	12	12	12	
Valuation Month-Current Month	Integer	11	10	9	8	7	6	5	4	3	2	1	0	
Compound Int To Valuation Month (Milk)	$	18.78409	16.86997	14.90793	13.03378	11.21427	9.498933	7.970303	6.459522	4.971507	3.392253	1.713599	0	108.81616
Compound Int To Valuation Month (Culls)	$	1.40807	1.374122	1.26494	1.111117	0.969011	0.810269	0.668288	0.538129	0.400639	0.259811	0.123612	0	8.928008
Compound Int To Valuation Month (Bulls)	$	0.350711	0.318686	0.286691	0.254725	0.222788	0.19088	0.158999	0.127146	0.09532	0.063521	0.031747	0	2.1012143
Compound Int To Valuation Month (Heifers)	$	0.420853	0.382423	0.344029	0.30567	0.267346	0.229056	0.190799	0.152575	0.114384	0.076225	0.038097	0	2.5214571
Compound Int To Valuation Month (Total)	$	20.96372	18.9452	16.80359	14.70529	12.67341	10.72914	8.988389	7.277373	5.58185	3.791809	1.907055	0	122.36684

Table 13A.3B Income & Expenses Per Month For Projected 1992 Costs & Returns For Milk Production Per Cow (Historic Cost Method) -- cont														
ITEM	**UNIT**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**ANNUAL**
Quantity Purchased														
Replacement Heifer	HD	0.033333	0.033333	0.033333	0.033333	0.033333	0.033333	0.033333	0.033333	0.033333	0.033333	0.033333	0.033333	0.4
Corn	Bu	11.25	11.25	11.25	11.25	11.25	11.25	11.25	11.25	11.25	11.25	11.25	11.25	135
Protein, Vit. & Min	cwt	1.06	1.06	1.06	1.06	1.06	1.06	1.06	1.06	1.06	1.06	1.06	1.06	12.72
Alfalfa Hay	ton	0.1825	0.1825	0.1825	0.1825	0.1825	0.1825	0.1825	0.1825	0.1825	0.1825	0.1825	0.1825	2.19
Alfalfa Haylage	ton	0.1975	0.1975	0.1975	0.1975	0.1975	0.1975	0.1975	0.1975	0.1975	0.1975	0.1975	0.1975	2.37
Corn Silage	ton	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33	3.96
Marketing	cwt	18	18	18	18	18	18	18	18	18	18	18	18	216
Purchase Price														
Replacement Heifer	$/HD	1119.72	1123.39	1127.06	1130.75	1134.46	1138.17	1141.90	1145.63	1149.38	1153.15	1156.92	1160.71	1140.1038
Corn	$/Bu	2.03	2.03	2.04	2.05	2.05	2.06	2.07	2.07	2.08	2.09	2.09	2.10	2.063
Protein, Vit. & Min	$/cwt	14.69	14.74	14.79	14.84	14.89	14.93	14.98	15.03	15.08	15.13	15.18	15.23	14.960
Alfalfa Hay	$/Ton	77.17	77.43	77.68	77.94	78.19	78.45	78.70	78.96	79.22	79.48	79.74	80.00	78.580
Alfalfa Haylage	$/Ton	72.35	72.59	72.83	73.06	73.30	73.54	73.78	74.03	74.27	74.51	74.76	75.00	73.669
Corn Silage	$/Ton	16.11	16.16	16.22	16.27	16.32	16.38	16.43	16.48	16.54	16.59	16.65	16.70	16.404
Marketing	$/cwt	0.47	0.47	0.47	0.47	0.48	0.48	0.48	0.48	0.48	0.48	0.49	0.49	0.478
Operating Costs														
Replacement Heifer	$	37.32403	37.44622	37.56881	37.6918	37.81519	37.93899	38.06319	38.1878	38.31282	38.43825	38.56408	38.69033	456.04152
Corn	$	22.79071	22.86532	22.94018	23.01528	23.09063	23.16622	23.24206	23.31815	23.39448	23.47107	23.54791	23.625	278.46701
Protein, Vit. & Min	$	15.5737	15.62469	15.67584	15.72716	15.77864	15.8303	15.88212	15.93412	15.98628	16.03862	16.09112	16.1438	190.28638
Alfalfa Hay	$	14.08442	14.13053	14.17679	14.2232	14.26976	14.31648	14.36335	14.41037	14.45754	14.50487	14.55236	14.6	172.08967
Alfalfa Haylage	$	14.28942	14.3362	14.38313	14.43022	14.47746	14.52485	14.5724	14.62011	14.66797	14.71599	14.76417	14.8125	174.5944
Corn Silage	$	5.316386	5.333791	5.351252	5.368771	5.386347	5.40398	5.421671	5.43942	5.457228	5.475093	5.493017	5.511	64.957956
Marketing	$	8.457248	8.484935	8.512713	8.540581	8.568541	8.596592	8.624735	8.65297	8.681298	8.709718	8.738231	8.766838	103.3344
Breeding	$	3.830276	3.842815	3.855395	3.868017	3.88068	3.893384	3.90613	3.918918	3.931747	3.944619	3.957532	3.970488	46.8
Veterinary & Medicine	$	5.280673	5.297961	5.315305	5.332706	5.350164	5.367679	5.385251	5.402881	5.420569	5.438314	5.456118	5.47398	64.5216
Supplies	$	12.76759	12.80938	12.85132	12.89339	12.9356	12.97795	13.02043	13.06306	13.10582	13.14873	13.19177	13.23496	156
Fuel & Oil	$	2.17575	2.182872	2.190019	2.197188	2.204381	2.211598	2.218838	2.226102	2.233389	2.240701	2.248036	2.255396	26.58427
Bedding	$													
Repairs (nominal $)	$	24.73	24.81	24.89	24.97	25.05	25.14	25.22	25.30	25.38	25.47	25.55	25.63	302.15052
Total (excluding dairy heifer)	$	129.2952	129.7185	130.1432	130.5692	130.9967	131.4255	131.8558	132.2874	132.7205	133.155	133.5909	134.0283	1579.7862
Total Operating Costs	$	166.6193	167.1647	167.712	168.261	168.8119	169.3645	169.919	170.4752	171.0333	171.5932	172.155	172.7186	2035.8277
Annual Nominal Int Rate	Decimal	0.092	0.092	0.092	0.092	0.092	0.092	0.092	0.092	0.092	0.092	0.092	0.092	
Monthly Compound Nominal Int Rate	Decimal	0.007361	0.007361	0.007361	0.007361	0.007361	0.007361	0.007361	0.007361	0.007361	0.007361	0.007361	0.007361	
Valuation Month(Dec=12, etc)	Integer	12	12	12	12	12	12	12	12	12	12	12	12	
Valuation Month-Current Month	Integer	11	10	9	8	7	6	5	4	3	2	1	0	
Compound Int To Valuation Month (no heifers	$	10.86342	9.871439	8.880375	7.890219	6.900958	5.912576	4.925061	3.938399	2.952575	1.967577	0.98339	0	65.085995
Compound Int To Valuation Month (inc heifers	$	13.9994	12.72106	11.4439	10.16791	8.893078	7.619377	6.346793	5.075308	3.804904	2.535563	1.267268	0	83.87456
Allocated Overhead														
Hired Labor	$	21.14	21.21	21.28	21.35	21.42	21.49	21.56	21.63	21.70	21.77	21.84	21.91	258.300
Opportunity Cost Of Unpaid Labor	$	19.92	19.99	20.06	20.12	20.19	20.25	20.32	20.39	20.45	20.52	20.59	20.65	243.448
Compound Int (Labor) To Valuation Month	$	3.45	3.14	2.82	2.51	2.19	1.88	1.56	1.25	0.94	0.62	0.31	0.00	20.672
Capital Recovery Of Livestock Inv														48.768048
Capital Recovery Of Machinery Inv														86.82
Capital Recovery Cost Of Bldg Inv														74.04
Taxes & Insurance														11.23
General Farm Overhead														99.46
Total Allocated Overhead														842.741
Total Cost														3418.485

Table 13A.4A A Sample Detailed CAR Summary for a Dairy Budget
1992 Projected Costs and Returns for Milk Production Per Cow, Detailed
(Use current value method used to account for cost of replacement heifers)
Ben & Bev Dairyman Farm, Upper Midwest, USA (See Chapter 14 for a complete description of the farm)
Prepared by John Q. Taskforce, Department of Agricultural Economics, Anonymous State University, March 1992

	Item	Units	Quantity	Price	Value
	Gross Value Of Production				
1	Milk (a)	cwt	216.00	12.28	2,652.04
2	Cull Cows (b)	cwt	4.68	45.56	213.22
3	Bull Calves (c)	hd	0.42	122.78	51.00
4	Heifer Calves (d)	hd	0.02	147.34	2.27
5	Interest On Receipts to December (e)			0.092	119.94
6	Total (f)				3,038.47
	Operating Costs				
7	Replacement Heifer (g)	hd	0.00	1140.10	0.00
8	Corn (h)	bu	143.40	2.06	295.79
9	Protein, Vit., & Min. (h)	cwt	13.82	14.96	206.74
10	Alfalfa Hay (h)	ton	2.85	78.58	223.89
11	Alfalfa Haylage (h)	ton	3.11	73.67	228.81
12	Corn Silage (h)	ton	5.20	16.40	85.32
13	Milk Replacer (h)	lbs	16.00	0.79	12.66
14	Marketing (milk) (i)	cwt	216.00	0.48	103.33
15	Breeding (j)	cow	1.00	64.98	64.98
16	Veterinary & Medicine (k)	cow	1.00	72.60	72.60
17	Supplies (k)	cow	1.00	161.96	161.96
18	Fuel, Oil, & Utilities (l)				30.27
19	Repairs (m)				328.53
20	Bedding (n)				14.40
21	Interest On Oper. Costs To Dec.(e)			0.092	75.37
22	Total Operating Costs (f)				1,904.65
	Allocated Overhead				
23	Hired Labor (o)				286.94
24	Opportunity Cost Of Unpaid Labor(o)				291.46
25	Opportunity Interest on Labor				23.83
26	Opportunity Interest On Livestock Investment (p)				60.32
27	Capital Recovery Of Mach & Eq Investment (q)				101.13
28	Capital Recovery of Bldg Investment (r)				92.56
29	Taxes & Insurance (s)				14.43
30	General Farm Overhead (t)				113.23
31	Total Allocated Overhead (f)				983.90
32	Total Costs Listed (f)				2,888.54
33	Value Of Prod. Less Total Oper. Costs (f)				1,133.82
34	Value Of Prod. Less Total Costs Listed (f)				149.92

TABLE 13A.4A 1992 Projected Costs and Returns for Milk Production Per Cow (Current Cost Method), Detailed Notes

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[a] See note [a] in Table 13.3.

[b] See note [b] in Table 13A.2.

[c] See note [c] in Table 13.3 for revenue from bull calf sales.

[d] It is assumed that 0.40 heifer calves per year are kept back to be raised for replacements. Given net births of .4154 heifers as discussed in footnote c of Table 13.3, this leaves 0.0154 calves to be sold. Although partial calves make no sense in this individual cow estimate, over a herd of 89 cows this would be 1.37 calves. As discussed in footnote c of Table 13.3 the average nominal price for the year is $147.34 giving revenue of $2.27. As with the cull cows, the calf sales are equally spaced during the year.

[e] See note [d] in Table 13.3. Interest on revenue in this Table is larger than in Table 13.3 due to the inclusion of cull cow sales as revenue. Interest on operating expenses is also larger due to the inclusion of the costs of raising a heifer as an additional operating expense.

[f] Individual values may not add to totals due to rounding.

[g] There is no charge here because the costs of raising the replacement are accounted for in the various expense totals such as feed, supplies, and vet-med.

[h] See note [g] in Table 13.3. In addition to the costs of feeding the cow accounted for in Table 13.3, this also includes the costs of feeding both young heifers (birth to 1 year) and yearling heifers (1 year to freshening) for one year. In particular it includes the cost of 0.40 of each type of heifer. These data are reported in Table 13A.7. For example, quantity of corn consumed from Table 13A.1 is 135 bushels, while the quantity from Table 13A.7 is 21 bushels. This then gives a total of 143.4 [135 + (0.4)(21)]. Note that Table 13A.7 assumes that the heifers are raised in a continuous fashion with expenses spaced equally over the year as opposed to Table 13A.6AB, which assume that each heifer is born on January 1.

[i] See note [h] in Table 13.3.

[j] See note [i] in Table 13.3. In addition to the breeding cost in Table 13.3 this includes the cost of breeding the replacement heifer taken from Table 13A.7. This then gives a cost of $64.98 [46.80 + (0.40)(45.4434)].

[k] See note [i] in Table 13.3 for vet-med and supplies. In addition to the costs in Table 13.3 this includes the cost of vet-med and supplies taken from Table 13A.7. This then gives a cost of $72.60 [64.52 + (0.40)(20.20)] for vet-med and $161.96 [156.00 + (0.40)(14.89)] for supplies.

TABLE 13A.4A Detailed Notes (continued)

[l] See note [j] in Table 13.3. In addition to the costs in Table 13.3 this includes the cost of fuel, oil, and utilities taken from Table 13A.7. This then gives a cost of $30.27 [26.58 + (0.40)(9.20)] allowing for rounding.

[m] See note [k] in Table 13.3. In addition to the costs in Table 13.3 this includes the repairs taken from Table 13A.7. This then gives a cost of $328.53 [302.15 + (0.40)(65.95)].

[n] Bedding is only used for raising replacement heifers. The cost is taken from Table 13A.7 and equals $14.40 [(0.40)(36)].

[o] See note [l] in Table 13.3. In addition to the costs in Table 13.3 this includes the labor costs taken from Table 13A.7. This then gives a cost of $286.94 [258.30 + (0.40)(71.5875)] for hired labor. A similar computation applies to own labor.

[p] Because we are using the current cost method, there is no capital recovery and cost is based on the opportunity interest associated with the investment in the cow and a yearling heifer since cull sales and heifer purchases are accounted for in other sections of the estimate. The traditional method of computing opportunity interest based on equations 6.5 and 6.6 (also equations 10.3 and 10.4) is used to obtain a value for investment. Specifically, we compute opportunity interest for the cow based on an average value of V_0 as follows

$$OC = \left(\frac{V_0 + V_n + D}{2} \right) (r)$$

where

V_0 = Value of the cow at the beginning of the first year in real terms
V_n = Value of the cow at the end (period n) of her useful life in real terms
D = Straight-line economic depreciation $D = \frac{V_0 - V_n}{n}$

OC = Opportunity interest cost
r = real interest rate
n = useful life in years.

V_0 is computed as in the historic cost method. The average value of the cow is then the same as in Table 13A.3 and is equal to $975.361. To this value of the cow we must add the value of a yearling heifer. Because we have no market data on this value, we use the cost of raising a heifer from birth to 1 year of age taken from Table 13A.5A, which is $577.67. This then gives an end-of-year value of $1,206.429 [975.361 + (0.40)(577.67)]. Opportunity interest is then $60.3214 [(1,206.429)(.05)].

TABLE 13A.4A Detailed Notes (continued)

[q] See note [n] in Table 13.3. In addition to the costs in Table 13.3 this includes machine and equipment investment taken from Table 13A.7. This then gives a cost of $101.13 [86.82 + (0.40)(35.7788)].

[r] See note [o] in Table 13.3. In addition to the costs in Table 13.3 this includes capital recovery for building investment taken from Table 13A.7. This then gives a cost of $92.56 [74.04 + (0.40)(46.28)] with appropriate rounding.

[s] See note [p] in Table 13.3. In addition to the tax and insurance costs in Table 13.3 this includes taxes and insurance taken from Table 13A.7 for the production of the heifer. This then gives a cost of $14.43 [11.23 + (0.40)(7.99)].

[t] See note [q] in Table 13.3. In addition to the overhead costs of $ 99.46 from Table 13.3, the general overhead costs of heifer production using the current cost method taken from Table 13A.7 are included. This gives a total overhead expense for the current cost method of $113.23 [99.46 + (0.40)(34.4269)].

Table 13A.4B Income & Expenses Per Month For Projected 1992 Costs & Returns For Milk Production Per Cow (Current Cost Method)														
ITEM	**UNIT**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**ANNUAL**
-----------------------	-------	-----------	-----------	-----------	-----------	-----------	-----------	-----------	-----------	-----------	-----------	-----------	-----------	------------
		1	2	3	4	5	6	7	8	9	10	11	12	
Quantity Sold														
Milk	cwt	18	18	18	18	18	18	18	18	18	18	18	18	216
Cull Cows	cwt	0.39	0.39	0.39	0.39	0.39	0.39	0.39	0.39	0.39	0.39	0.39	0.39	4.68
Bull Calves	HD	0.03462	0.03462	0.03462	0.03462	0.03462	0.03462	0.03462	0.03462	0.03462	0.03462	0.03462	0.03462	0.4153846
Heifer Calves	HD	0.00128	0.00128	0.00128	0.00128	0.00128	0.00128	0.00128	0.00128	0.00128	0.00128	0.00128	0.00128	0.0153846
Sale Price														
Milk	$/cwt	12.42	12.32	12.14	11.98	11.83	11.73	11.85	12.05	12.42	12.75	12.93	12.91	12.277969
Cull Cows	$/cwt	42.97	46.30	47.53	47.15	47.16	46.18	45.88	46.35	46.18	45.08	43.06	42.87	45.55924
Bull Calves	$/HD	120.59	120.98	121.38	121.77	122.17	122.57	122.97	123.38	123.78	124.19	124.59	125.00	122.78087
Heifer Calves	$/HD	144.70	145.18	145.65	146.13	146.61	147.09	147.57	148.05	148.54	149.02	149.51	150.00	147.33704
Value Of Production														
Milk	$	223.566	221.685	218.478	215.686	212.874	211.144	213.384	216.97	223.473	229.569	232.788	232.425	2652.0413
Cull Cows	$	16.7587	18.0571	18.5379	18.387	18.3942	18.0108	17.8917	18.0753	18.009	17.5826	16.7924	16.7207	213.21724
Bull Calves	$	4.17412	4.18779	4.2015	4.21525	4.22905	4.2429	4.25679	4.27072	4.2847	4.29873	4.3128	4.32692	51.001285
Heifer Calves	$	0.18552	0.18612	0.18673	0.18734	0.18796	0.18857	0.18919	0.18981	0.19043	0.19105	0.19168	0.19231	2.2667238
Total Revenue		244.684	244.116	241.404	238.476	235.685	233.586	235.722	239.506	245.957	251.642	254.085	253.665	2918.5265
Annual Nominal Int Rate	Decimal	0.092	0.092	0.092	0.092	0.092	0.092	0.092	0.092	0.092	0.092	0.092	0.092	
Monthly Compound Int Rate	Decimal	0.00736	0.00736	0.00736	0.00736	0.00736	0.00736	0.00736	0.00736	0.00736	0.00736	0.00736	0.00736	
Valuation Month(Dec=12, etc)	Integer	12	12	12	12	12	12	12	12	12	12	12	12	
Valuation Month-Current Month	Integer	11	10	9	8	7	6	5	4	3	2	1	0	
Compound Int To Valuation Month (Milk)	$	18.7841	16.87	14.9079	13.0338	11.2143	9.49893	7.9703	6.45952	4.97151	3.39225	1.7136	0	108.81616
Compound Int To Valuation Month (Culls)	$	1.40807	1.37412	1.26494	1.11112	0.96901	0.81027	0.66829	0.53813	0.40064	0.25981	0.12361	0	8.928008
Compound Int To Valuation Month (Bulls)	$	0.35071	0.31869	0.28669	0.25473	0.22279	0.19088	0.159	0.12715	0.09532	0.06352	0.03175	0	2.1012143
Compound Int To Valuation Month (Heifers)	$	0.01559	0.01416	0.01274	0.01132	0.0099	0.00848	0.00707	0.00565	0.00424	0.00282	0.00141	0	0.0933873
Compound Int To Valuation Month (Total)	$	20.5585	18.5769	16.4723	14.4109	12.416	10.5086	8.80466	7.13045	5.4717	3.71841	1.87037	0	119.93877

Table 13A.4B Income & Expenses Per Month For Projected 1992 Costs & Returns For Milk Production Per Cow (Current Cost Method) -- cont

ITEM	UNIT	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	ANNUAL
Quantity Purchased														
Replacement Heifer	HD	0	0	0	0	0	0	0	0	0	0	0	0	0
Corn	Bu	11.95	11.95	11.95	11.95	11.95	11.95	11.95	11.95	11.95	11.95	11.95	11.95	143.4
Protein, Vit. & Min	cwt	1.15167	1.15167	1.15167	1.15167	1.15167	1.15167	1.15167	1.15167	1.15167	1.15167	1.15167	1.15167	13.82
Alfalfa Hay	ton	0.23743	0.23743	0.23743	0.23743	0.23743	0.23743	0.23743	0.23743	0.23743	0.23743	0.23743	0.23743	2.8492
Alfalfa Haylage	ton	0.25883	0.25883	0.25883	0.25883	0.25883	0.25883	0.25883	0.25883	0.25883	0.25883	0.25883	0.25883	3.106
Corn Silage	ton	0.43343	0.43343	0.43343	0.43343	0.43343	0.43343	0.43343	0.43343	0.43343	0.43343	0.43343	0.43343	5.2012
Milk Replacer	lbs	1.33333	1.33333	1.33333	1.33333	1.33333	1.33333	1.33333	1.33333	1.33333	1.33333	1.33333	1.33333	16
Marketing	cwt	18	18	18	18	18	18	18	18	18	18	18	18	216
Purchase Price														
Replacement Heifer	$/HD	1119.72	1123.39	1127.06	1130.75	1134.46	1138.17	1141.90	1145.63	1149.38	1153.15	1156.92	1160.71	1140.1038
Corn	$/Bu	2.03	2.03	2.04	2.05	2.05	2.06	2.07	2.07	2.08	2.09	2.09	2.10	2.063
Protein, Vit. & Min	$/cwt	14.69	14.74	14.79	14.84	14.89	14.93	14.98	15.03	15.08	15.13	15.18	15.23	14.960
Alfalfa Hay	$/Ton	77.17	77.43	77.68	77.94	78.19	78.45	78.70	78.96	79.22	79.48	79.74	80.00	78.580
Alfalfa Haylage	$/Ton	72.35	72.59	72.83	73.06	73.30	73.54	73.78	74.03	74.27	74.51	74.76	75.00	73.669
Corn Silage	$/Ton	16.11	16.16	16.22	16.27	16.32	16.38	16.43	16.48	16.54	16.59	16.65	16.70	16.404
Milk Replacer	$/lbs	0.7885	0.7885	0.7885	0.7885	0.7885	0.7885	0.7885	0.7885	0.7885	0.7885	0.7885	**0.8200**	0.7911
Marketing	$/cwt	0.47	0.47	0.47	0.47	0.48	0.48	0.48	0.48	0.48	0.48	0.49	0.49	0.478
Operating Cost														
Replacement Heifer	$	0	0	0	0	0	0	0	0	0	0	0	0	0
Corn	$	24.2088	24.2881	24.3676	24.4473	24.5274	24.6077	24.6882	24.7691	24.8501	24.9315	25.0131	25.095	295.79385
Protein, Vit. & Min	$	16.9205	16.9759	17.0315	17.0872	17.1431	17.1993	17.2556	17.3121	17.3687	17.4256	17.4826	17.5399	206.74197
Alfalfa Hay	$	18.3239	18.3839	18.4441	18.5044	18.565	18.6258	18.6868	18.748	18.8093	18.8709	18.9327	18.9947	223.88944
Alfalfa Haylage	$	18.727	18.7883	18.8498	18.9115	18.9734	19.0355	19.0978	19.1604	19.2231	19.286	19.3492	19.4125	228.81443
Corn Silage	$	6.98272	7.00558	7.02852	7.05153	7.07461	7.09777	7.12101	7.14432	7.16771	7.19118	7.21472	7.23834	85.318011
Milk Replacer	$	1.0513	1.0513	1.0513	1.0513	1.0513	1.0513	1.0513	1.0513	1.0513	1.0513	1.0513	1.0933	12.6574
Marketing	$	8.45725	8.48494	8.51271	8.54058	8.56854	8.59659	8.62473	8.65297	8.6813	8.70972	8.73823	8.76684	103.3344
Breeding	$	5.31797	5.33538	5.35285	5.37037	5.38796	5.40559	5.42329	5.44105	5.45886	5.47673	5.49466	5.51265	64.977361
Veterinary & Medicine	$	5.94197	5.96142	5.98094	6.00052	6.02016	6.03987	6.05964	6.07948	6.09938	6.11935	6.13938	6.15948	72.6016
Supplies	$	13.255	13.2984	13.342	13.3857	13.4295	13.4734	13.5175	13.5618	13.6062	13.6507	13.6954	13.7403	161.956
Fuel & Oil	$	2.47701	2.48512	2.49325	2.50141	2.5096	2.51782	2.52606	2.53433	2.54263	2.55095	2.5593	2.56768	30.265169
Bedding	$	1.17855	1.1824	1.18628	1.19016	1.19406	1.19796	1.20189	1.20582	1.20977	1.21373	1.2177	1.22169	14.4
Repairs (nominal $)	$	26.8879	26.976	27.0643	27.1529	27.2418	27.3309	27.4204	27.5102	27.6003	27.6906	27.7813	27.8722	328.52871
Total Operating Costs	$	149.73	150.217	150.705	151.195	151.686	152.18	152.674	153.171	153.669	154.168	154.67	155.215	1829.2784
Annual Nominal Int Rate	Decimal	0.092	0.092	0.092	0.092	0.092	0.092	0.092	0.092	0.092	0.092	0.092	0.092	
Monthly Compound Nominal Int Rate	Decimal	0.00736	0.00736	0.00736	0.00736	0.00736	0.00736	0.00736	0.00736	0.00736	0.00736	0.00736	0.00736	
Valuation Month(Dec=12, etc)	Integer	12	12	12	12	12	12	12	12	12	12	12	12	
Valuation Month-Current Month	Integer	11	10	9	8	7	6	5	4	3	2	1	0	
Compound Int To Valuation Month	$	12.5804	11.4313	10.2834	9.13662	7.9909	6.84626	5.70267	4.56012	3.4186	2.27808	1.13855	0	75.366903
Allocated Overhead														
Hired Labor	$	23.4838	23.5607	23.6378	23.7152	23.7928	23.8707	23.9489	24.0273	24.1059	24.1849	24.264	24.3435	286.935
Opportunity Cost Of Unpaid Labor	$	23.8545	23.9326	24.0109	24.0896	24.1684	24.2475	24.3269	24.4066	24.4865	24.5666	24.647	24.7277	291.465
Compound Int (Labor) To Valuation Month	$	3.98	3.61	3.25	2.89	2.53	2.16	1.80	1.44	1.08	0.72	0.36	0.00	23.830
Capital Recovery Of Livestock Inv														60.321445
Capital Recovery Of Machinery Inv														101.13138
Capital Recovery of Bldg Inv														92.556086
Taxes & Insurance														14.432863
General Farm Overhead														113.22632
Total Allocated Overhead														983.898
Total Costs														2888.543

Table 13A.5A A Sample Detailed CAR Summary for a Dairy Budget
1992 Projected Costs for Production of a Dairy Heifer (birth to 1 year of age)

Ben & Bev Dairyman Farm, Upper Midwest, USA (See Chapter 14 for a complete description of the farm)
Prepared by John Q. Taskforce, Department of Agricultural Economics, Anonymous State University, March 1992

	Item	Units	Quantity	Price (a)	Value (b)
	Operating Costs				
1	Purchase of heifer calf (c)	hd	1.00	144.23	144.23
2	Corn (d)	bu	17.00	2.06	35.14
3	Protein, Vit., & Min. (d)	cwt	2.00	14.96	29.94
4	Alfalfa Hay (d)	ton	0.39	78.58	30.72
5	Alfalfa Haylage (d)	ton	0.43	73.67	31.92
6	Corn Silage (d)	ton	0.73	16.40	12.11
7	Milk Replacer (d)	lbs	40.00	0.81	31.75
8	Breeding (e)	cow	1.00	0	0.00
9	Veterinary & Medicine (f)	cow	1.00	13.00	13.00
10	Supplies (f)	cow	1.00	2.89	2.89
11	Fuel, Oil, & Utilities (g)				4.60
12	Bedding (h)				24.00
13	Repairs (i)				32.97
14	Interest On Oper. Costs To Dec.(j)			0.092	22.40
15	Total Operating Costs (k)				415.67
	Allocated Overhead				
16	Hired Labor (l)				35.79
17	Opportunity Cost Of Unpaid Labor(l)				60.02
18	Opportunity Interest on Labor				3.95
19	Capital Recovery Of Livestock Investment (m)				0.00
20	Capital Recovery Of Mach & Eq Investment (n)				17.89
21	Capital Recovery of Bldg Investment (o)				23.14
22	Taxes & Insurance (p)				4.00
23	General Farm Overhead (q)				17.21
24	Total Allocated Overhead (k)				162.00
25	Total Costs Listed (k)				577.67

TABLE 13A.5A 1992 Projected Costs for Production of a Dairy Heifer (birth to 1 year of age) Detailed Notes

[a] The prices reported in this column are the average nominal prices for the year. They are the simple average of the monthly prices.

[b] The product of price and quantity in this table will not generally be equal to cost because the quantities often vary by month. When quantities vary, the average price multiplied by the total quantity will not give total expenditure. The monthly expenditures that sum to the value in this column are given in Table 13A.6A.

[c] We assume that a heifer calf is purchased on January 1. The nominal (and real) cost of the calf on December 31 is $150. The nominal value on January 1 is $144.23 [(150)/(1.04)].

[d] Annual feed consumption is 17 bushels of corn, 200 pounds of a protein/vitamin/mineral premix, 0.39 tons of alfalfa, 0.43 tons of alfalfa haylage, and 0.73 tons of corn silage. These annual consumption amounts are based on historical data for the Dairyman operation and information on ration formulation available from the Minnesota Extension Service. These quantities are not evenly spaced over the year but vary depending on the age of the calf. Actual quantities per month are provided here in Table 13A.6A.

		Jan	Feb	Mar	Apr	May	Jun	July	Aug	Sep	Oct	Nov	Dec	Total
Corn	bu	0.50	1.00	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	2.00	17.00
Protein, Vit, & Min	cwt	0.15	0.15	0.15	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.18	0.18	2.000
Alfalfa Hay	ton	0.01	0.01	0.01	0.01	0.02	0.03	0.04	0.04	0.05	0.05	0.06	0.07	0.388
Alfalfa Haylage	ton	0.01	0.01	0.01	0.01	0.02	0.03	0.04	0.05	0.05	0.06	0.07	0.08	0.430
Corn Silage	ton	0.01	0.01	0.01	0.03	0.05	0.06	0.07	0.08	0.09	0.10	0.11	0.12	0.733
Milk Replacer	lbs	12.00	14.00	14.00										40.00

The prices, which are the same as in Table 13.3, are the nominal averages for the year and reflect net market prices the farm would receive. The prices are not seasonally adjusted. The monthly prices are as follows.

	Jan	Feb	Mar	Apr	May	Jun	July	Aug	Sep	Oct	Nov	Dec	Nominal Average	Real Average
Corn	2.03	2.03	2.04	2.05	2.05	2.06	2.07	2.07	2.08	2.09	2.09	2.10	2.06	2.10
Pre-mix	14.69	14.74	14.79	14.84	14.89	14.93	14.98	15.03	15.08	15.13	15.18	15.23	14.96	15.23
Alfalfa Hay	77.17	77.43	77.68	77.94	78.19	78.45	78.70	78.96	79.22	79.48	79.74	80.00	78.58	80.00
Alfalfa Haylage	72.35	72.59	72.83	73.06	73.30	73.54	73.78	74.03	74.27	74.51	74.76	75.00	73.67	75.00
Corn Silage	16.11	16.16	16.22	16.27	16.32	16.38	16.43	16.48	16.54	16.59	16.65	16.70	16.40	16.70

[e] There is no breeding charge because the animal is less than one year of age.

TABLE 13A.5A Detailed Notes (continued)

[f] Based on total nominal expenditures as recorded in farm records for these livestock inputs in 1991 on a yearling to freshening animal basis. Total expenditures are adjusted forward assuming a 4% inflation rate. The projected 1992 levels are listed in Table 13A.6A and below and are nominal values per month that sum to the nominal total.

Expense for 1992	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**July**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Total**
Veterinary & Medicine	3.00	3.00	1.00	0.75	0.72	0.71	0.70	0.67	0.65	0.60	0.60	0.60	13.00
Supplies	0.35	0.30	0.28	0.25	0.25	0.24	0.22	0.20	0.20	0.20	0.20	0.20	2.89

[g] Data in Schedule 14.8 indicate $2,275 [(3,500)(.65)] of expense for 89 cows, or $25.56 per cow for fuel, oil, and utilities. It is assumed that these are spaced equally throughout the year for the purpose of computing operating interest. Like the items in footnote [i], this expenditure is adjusted for inflation and then allocated across months such that real expenditures per month are equal. Average nominal expenditure is $26.58 [(25.56)(1.04)].

[h] Bedding expenses are based on 1991 data for Ben's operation and are adjusted forward using a 4% annual inflation rate. Data on a monthly basis are available and differ by month because a young calf uses more bedding. The values in Table 13A.6A are projected nominal 1992 values that sum to the total annual expenditure.

[i] Annual Repairs for Buildings and Equipment for Heifer Calves

Repair costs are computed as in footnote [k] of Table 13.3 using standard repair cost formulas for equipment. Costs for the other items are computed using the previous year's expenditures adjusted for inflation (4%). The percent allocated to replacement animals is based on 1991 data and is summarized in the following table.

		Annual Expense	Percent for Replacements	Repairs for Cows
Manure Equipment (Schedule 14.7)	$34.744/hr x 200 hr =	$6,948.87	20	1,389.77
Feed Hdl. Equipment (Schedule 14.7)	6.4528/hr x 133 hr =	858.22	20	171.64
Milking Equipment (Schedule 14.7)	3.6567/hr x 1100 hr =	4,022.36	0	0.00
Repairs to Dairy Bldg. (Schedule 14.6 footnote d)		10,944.96	0	0.00
Buildings & Improvements (Schedule 14.8)		7,451.60	9	670.64
Machinery & Equipment (Schedule 14.8)		1,284.40	9	115.60
				2,347.66

Estimated repairs per replacement (71.2)	**32.97**

TABLE 13A.5A Detailed Notes (continued)

The number of replacements is based on Ben's replacement rate of 0.40 and the fact that he has two animals in inventory for every replacement (one calf and one yearling). The number (71.2) is derived by multiplying the number of cows (89) by the replacement rate (0.40) and then doubling it. It was decided to use the decimal (71.2) rather than rounding to the integer 71 because that is the way other fractional amounts were handled.

Ben does not have any data on the allocation of repair expenditures over the year. After discussion with him, it was decided to assume that total real repair expense was spaced equally throughout the year for the purpose of computing operating interest. As suggested in Chapter 5, because the repair costs are in nominal (also real) values at the end of the year and expenditures will be at an earlier point in time, it is appropriate to deflate these before computing nominal interest. The procedure suggested in [i] and [j] of Table 13.3 is followed to find a constant real payment, which is then adjusted for inflation. The computations are contained in Table 13A.6A and repeated here.

Real Prices	**Real Cost Per Month**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**July**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Nominal Average Cost**	**Nominal Total Cost**
Cow Repairs (Real)	25.6343	25.63	25.63	25.63	25.63	25.63	25.63	25.63	25.63	25.63	25.63	25.63	25.63	25.63	**302.1505**
Replacement Repairs (Real)	2.7974	2.80	2.80	2.80	2.80	2.80	2.80	2.80	2.80	2.80	2.80	2.80	2.80	2.80	**32.9727**
Cow Repairs (Nominal)		24.73	24.81	24.89	24.97	25.05	25.14	25.22	25.30	25.38	25.47	25.55	25.63	25.18	**302.1505**
Replacement Repairs (Nominal)		2.70	2.71	2.72	2.73	2.73	2.74	2.75	2.76	2.77	2.78	2.79	2.80	2.75	**32.9727**

[j] All receipts and expenses are assumed to occur on the last day of the month. Interest is compounded at the monthly rate of .00736 $\left[(1.092)^{\frac{1}{12}} - 1\right]$, (equivalent to an annual rate of .092) until the last day of December. For example, the interest expense on replacement repairs in August is computed as $(2.76)(1.092)^{4/12} - 2.76 = \$0.082$. These are summed across categories and months to obtain the total.

[k] Individual values may not sum to totals due to rounding.

TABLE 13A.5A Detailed Notes (continued)

[l] Livestock labor is based on labor use in 1991 (Schedule 14.4). We assume 71.2 replacements as with repair expenses. The hours per animal are as follows.

Worker	Total Livestock Hours	Total Cows Hours	Total Young Stock Hours	Per Replacement Hours	Wage $/hour 1991	Wage $/hour 1992	Per Replacement Cost
Operator	2,437	2,193	244	3.427	$9.50	$9.88	$33.86
Son	330	0	330	4.635	$5.43	$5.64	$26.16
Hired Worker 1	2,173	1,956	217	3.048	$9.47	$9.85	$30.01
Hired Worker 2	734	661	73	1.025	$5.43	$5.64	$5.79
Total Hired							$35.79

The costs per hour are computed as in footnote [l] of Table 13.3. It is assumed that labor quantities in 1991 and 1992 are the same. The labor expenditures (such as hours) are assumed to be equally spaced over the year so that each worker (including the unpaid ones) is paid a monthly salary. These expenditures are allocated in a manner similar to items in footnotes [i], [j], and [k] of Table 13.3 where a constant real payment over the months is assumed. The actual monthly expenditures in real and nominal terms are as follows.

Expenditure	Jan	Feb	Mar	Apr	May	Jun	July	Aug	Sep	Oct	Nov	Dec	Average	Total
Month #	1	2	3	4	5	6	7	8	9	10	11	12		
Hired Labor Nominal	2.93	2.94	2.95	2.96	2.97	2.98	2.99	3.00	3.01	3.02	3.03	3.04	2.9828	35.794
Family Labor Nominal	4.91	4.93	4.94	4.96	4.98	4.99	5.01	5.03	5.04	5.06	5.08	5.09	5.0018	60.022
Opportunity Interest	0.66	0.60	0.54	0.48	0.42	0.36	0.30	0.24	0.18	0.12	0.06	0.00		3.948

The nominal average expenditure multiplied by 12 will give the nominal expenditure for the year. Opportunity interest at a nominal rate is charged because most employees are paid monthly and the family makes monthly withdrawals. For example, the opportunity interest on the January expense is given by $(7.84)(1.092)^{11/12} - 7.84 = .658$.

[m] Because there is no cow involved, there is no capital recovery for her. The cow's implicit cost is accounted for in the cost of the calf in footnote [c].

[n] Capital recovery is based on the difference between the beginning value of the various pieces of equipment and their real salvage value at the end of their useful life. This salvage value is discounted back to the present at a real interest rate of 5% and then subtracted from the initial value to obtain a net present cost of the equipment. This is then converted to a real annual annuity following the procedures outlined in Chapter 2 and equation 6.7. A more complete discussion of the equipment for this example is contained in note [n] of Table 13.3. The following table summarizes the results.

TABLE 13A.5A Detailed Notes (continued)

	Livestock	Heifers Percent	Heifers Annual
Manure Equipment	$4,005.62	20	$801.12
Feed Handling Equipment	2,363.00	20	472.60
Milking Equipment	2,632.06	0	0.00
Annual Total	$10,909.36		$1,273.72
Capital Recovery/Replacement (71.2 heifers)			$17.89

[o] The buildings for livestock have an estimated market value of $87,000 (Schedule 14.6). The opportunity cost of this capital is valued at a 5% real rate and a 9.2% nominal rate. The estimated life of each item is given in Schedule 14.6. Equation 6.7 is used to compute capital recovery. Twenty percent of the opportunity cost is allocated to the replacements. The data and computations are presented in footnote [o] of Table 13.3 and summarized here.

	Inflation Adjusted Annuity	**Percent for Replacements**	**Annuity for Replacements**
Manure Pit	269.3695	20	53.874
Harvestor 1	667.6183	20	133.524
Heifer Barn	417.2615	20	83.452
Harvestor 2	1,669.0458	20	333.809
Dairy Barn	4,007.8392	20	801.568
Stave Silo 1	417.2615	20	83.452
Stave Silo 2	134.6848	20	26.937
Old Barn	404.0543	20	80.811
Hay Shed	250.3569	20	50.071
Total	8,237.492		1,647.498
Total Annual Cost	1,647.498		
Number of Heifers	71.2		
Cost per Heifer	23.14		

[p] Taxes and insurance are calculated from the data in Schedule 14.8. Approximately 6% of the real estate tax and 9% of the farm insurance is allocated to the replacements. These expenses are adjusted forward for inflation so that 1992 values are 4% higher. Real estate taxes for this replacements are [(0.06)(3,244)(1.04)] or $202.43. Insurance is [(0.09)(880)(1.04)] or $82.37. The costs per heifer (assuming 71.2 heifers in the herd) are $2.84 and $1.16, respectively, for a total of $4.00.

TABLE 13A.5A Detailed Notes (continued)

[q] General farm overhead includes the replacements' share (9%) of office expenses (Schedule 14.8) adjusted for inflation. The total overhead is $13,094 (1,194+3,500+7,165+1,235). Multiplying by 0.09, adjusting for inflation, and dividing by the number of replacements gives $\left[\frac{(13,094)(0.09)(1.04)}{71.2}\right] = \$17.21$ per heifer.

Table 13A.5B A Sample Detailed CAR Summary for a Dairy Budget
1992 Projected Costs for Production of a Dairy Heifer (1 year of age to freshening)

Ben & Bev Dairyman Farm, Upper Midwest, USA (See Chapter 14 for a complete description of the farm)
Prepared by John Q. Taskforce, Department of Agricultural Economics, Anonymous State University, March 1992

	Item	Units	Quantity	Price (a)	Value (b)
	Operating Costs				
1	Purchase of heifer calf (c)	hd	1.00	0.00	0.00
2	Corn (d)	bu	4.00	2.06	8.25
3	Protein, Vit., & Min. (d)	cwt	0.75	14.96	11.22
4	Alfalfa Hay (d)	ton	1.26	78.58	99.01
5	Alfalfa Haylage (d)	ton	1.41	73.67	103.87
6	Corn Silage (d)	ton	2.37	16.40	38.88
7	Milk Replacer (d)	lbs	0.00	0.81	0.00
8	Breeding (e)	cow	1.00	45.44	45.44
9	Veterinary & Medicine (f)	cow	1.00	7.20	7.20
10	Supplies (f)	cow	1.00	12.00	12.00
11	Fuel, Oil, & Utilities (g)				4.60
12	Bedding (h)				12.00
13	Repairs (i)				32.97
14	Interest On Oper. Costs To Dec.(j)			0.092	16.70
15	Total Operating Costs (k)				392.15
	Allocated Overhead				
16	Hired Labor (l)				35.79
17	Opportunity Cost Of Unpaid Labor(l)				60.02
18	Opportunity Interest on Labor				3.95
19	Capital Recovery Of Livestock Investment (m)				0.00
20	Capital Recovery Of Mach & Eq Investment (n)				17.89
21	Capital Recovery of Bldg Investment (o)				23.14
22	Taxes & Insurance (p)				4.00
23	General Farm Overhead (q)				17.21
24	Total Allocated Overhead (k)				162.00
25	Total Costs Listed (k)				554.16

TABLE 13A.5B 1992 Projected Costs for Production of a Dairy Heifer (1 year of age to freshening) Detailed Notes

[a] The prices reported in this column are the average nominal prices for the year. They are the simple average of the monthly prices.

[b] The product of price and quantity in this table will not generally be equal to cost because the quantities often vary by month. When quantities vary, the average price multiplied by the total quantity will not give total expenditure. The monthly expenditures that sum to the value in this column are given in Table 13A.6B.

[c] The heifer calf is assumed to come from the herd and no charge is included here.

[d] Annual feed consumption is 4 bushels of corn, 75 pounds of a protein/vitamin/mineral premix, 1.26 tons of alfalfa, 1.41 tons of alfalfa haylage, and 2.37 tons of corn silage. These annual consumption amounts are based on historical data for the Dairyman operation and information on ration formulation available from the Minnesota Extension Service. These quantities are not evenly spaced over the year but vary depending on the age of the calf. Actual quantities per month are presented here and in Table 13A.6B.

		Jan	Feb	Mar	Apr	May	Jun	July	Aug	Sep	Oct	Nov	Dec	Total
Corn	bu	0.330	0.330	0.330	0.330	0.330	0.330	0.330	0.330	0.340	0.340	0.340	0.340	4.000
Protein, Vit, & Min	cwt	0.063	0.063	0.063	0.063	0.063	0.063	0.063	0.063	0.063	0.063	0.063	0.063	0.750
Alfalfa Hay	ton	0.105	0.105	0.105	0.105	0.105	0.105	0.105	0.105	0.105	0.105	0.105	0.105	1.260
Alfalfa Haylage	ton	0.118	0.118	0.118	0.118	0.118	0.118	0.118	0.118	0.118	0.118	0.118	0.118	1.410
Corn Silage	ton	0.198	0.198	0.198	0.198	0.198	0.198	0.198	0.198	0.198	0.198	0.198	0.198	2.370

The prices are the same as in Table 13.3 and footnote [d] of Table 13A.5A.

[e] The breeding charge is a nominal value of $45.44 that occurs in March.

[f] Based on total nominal expenditures as recorded in farm records for these livestock inputs in 1991 on a per birth to yearling animal basis. Total expenditures are adjusted forward assuming a 4% inflation rate. The projected 1992 levels are listed in Table 13A.6A and below, and are nominal values per month that sum to the nominal total.

Expense for 1992	Jan	Feb	Mar	Apr	May	Jun	July	Aug	Sep	Oct	Nov	Dec	Total
Veterinary & Medicine	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	7.20
Supplies	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	12.00

[g]-[q] See notes [g]-[q] in Table 13A.5A. These costs are the same for both a calf (birth to 1 year of age) and a yearling.

Table 13A.6A Expenses Per Month For 1992 Projected Costs & Returns For Heifer Production (0-12) months														
ITEM	**UNIT**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**ANNUAL**
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		1	2	3	4	5	6	7	8	9	10	11	12	
Quantity Purchased														
Heifer Calf (Jan 1 purchase)	HD	1.0000												1.0000
Corn	bu	0.50	1.00	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	2.00	17.0000
Protein, Vit. & Min	cwt	0.15	0.15	0.15	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.18	0.18	2.0000
Alfalfa Hay	ton	0.01	0.01	0.01	0.01	0.02	0.03	0.04	0.04	0.05	0.05	0.06	0.07	0.3880
Alfalfa Haylage	ton	0.01	0.01	0.01	0.01	0.02	0.03	0.04	0.05	0.05	0.06	0.07	0.08	0.4300
Corn Silage	ton	0.01	0.01	0.01	0.03	0.05	0.06	0.07	0.08	0.09	0.10	0.11	0.12	0.7330
Milk Replacer	lbs	12.00	14.00	14.00										40.0000
Purchase Price														
Heifer Calf (Jan 1 Purchase)	$/HD	144.2308												144.2308
Corn	$/Bu	2.0258	2.0325	2.0391	2.0458	2.0525	2.0592	2.0660	2.0727	2.0795	2.0863	2.0931	2.1000	2.0627
Protein, Vit. & Min	$/cwt	14.6922	14.7403	14.7885	14.8369	14.8855	14.9342	14.9831	15.0322	15.0814	15.1308	15.1803	15.2300	14.9596
Alfalfa Hay	$/Ton	77.1749	77.4276	77.6810	77.9353	78.1905	78.4465	78.7033	78.9609	79.2194	79.4788	79.7390	80.0000	78.5798
Alfalfa Haylage	$/Ton	72.3515	72.5883	72.8260	73.0644	73.3036	73.5436	73.7843	74.0259	74.2682	74.5113	74.7553	75.0000	73.6685
Corn Silage	$/Ton	16.1103	16.1630	16.2159	16.2690	16.3223	16.3757	16.4293	16.4831	16.5371	16.5912	16.6455	16.7000	16.4035
Milk Replacer	$/lbs	0.7910	0.7936	0.7962	0.7988	0.8015	0.8041	0.8067	0.8093	0.8120	0.8147	0.8173	0.8200	0.8054
Operating Costs														
Replacement Heifer	$	144.2308	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	144.2308
Corn	$	1.0129	2.0325	3.0587	3.0687	3.0788	3.0888	3.0989	3.1091	3.1193	3.1295	3.1397	4.2000	35.1369
Protein, Vit. & Min	$	2.2038	2.2110	2.2183	2.5223	2.5305	2.5388	2.5471	2.5555	2.5638	2.5722	2.7325	2.7414	29.9373
Alfalfa Hay	$	0.4630	0.4646	0.5438	0.7014	1.5638	2.3534	3.1481	3.1584	3.9610	3.9739	4.7843	5.6000	30.7158
Alfalfa Haylage	$	0.4341	0.4355	0.5826	0.7306	1.4661	2.2063	2.9514	3.7013	3.7134	4.4707	5.2329	6.0000	31.9249
Corn Silage	$	0.0967	0.1131	0.1622	0.4881	0.8161	0.9825	1.1501	1.3186	1.4883	1.6591	1.8310	2.0040	12.1098
Milk Replacer	$	9.4925	11.1109	11.1472	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	31.7506
Breeding	$	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Veterinary & Medicine	$	3.0000	3.0000	1.0000	0.7500	0.7200	0.7100	0.7000	0.6700	0.6500	0.6000	0.6000	0.6000	13.0000
Supplies	$	0.3500	0.3000	0.2800	0.2500	0.2500	0.2400	0.2200	0.2000	0.2000	0.2000	0.2000	0.2000	2.8900
Fuel & Oil	$	0.3766	0.3778	0.3790	0.3803	0.3815	0.3828	0.3840	0.3853	0.3865	0.3878	0.3891	0.3904	4.6011
Bedding	$	3.0000	3.0000	2.7500	2.5000	2.2500	2.0000	2.0000	1.5000	1.5000	1.5000	1.0000	1.0000	24.0000
Repairs (nominal $)	$	2.6986	2.7074	2.7163	2.7252	2.7341	2.7431	2.7520	2.7611	2.7701	2.7792	2.7883	2.7974	32.9727
Total (excluding dairy heifer)	$	23.1283	25.7528	24.8381	14.1166	15.7909	17.2457	18.9517	19.3593	20.3525	21.2724	22.6977	25.5331	249.0392
Total Operating Costs	$	167.3590	25.7528	24.8381	14.1166	15.7909	17.2457	18.9517	19.3593	20.3525	21.2724	22.6977	25.5331	393.2699
Annual Nominal Int Rate	Decimal	0.0920	0.0920	0.0920	0.0920	0.0920	0.0920	0.0920	0.0920	0.0920	0.0920	0.0920	0.0920	
Monthly Compound Nominal Int Rate	Decimal	0.0074	0.0074	0.0074	0.0074	0.0074	0.0074	0.0074	0.0074	0.0074	0.0074	0.0074	0.0074	
Valuation Month(Dec=12, etc)	Integer	12	12	12	12	12	12	12	12	12	12	12	12	
Valuation Month-Current Month	Integer	11	10	9	8	7	6	5	4	3	2	1	0	
Compound Int To Valuation Month (no heifers)	$	1.9432	1.9598	1.6948	0.8531	0.8319	0.7759	0.7079	0.5764	0.4528	0.3143	0.1671	0.0000	10.2771
Compound Int To Valuation Month (inc heifers)	$	14.0616	1.9598	1.6948	0.8531	0.8319	0.7759	0.7079	0.5764	0.4528	0.3143	0.1671	0.0000	22.3954
Allocated Overhead														
Hired Labor	$	2.9295	2.9391	2.9487	2.9584	2.9680	2.9778	2.9875	2.9973	3.0071	3.0169	3.0268	3.0367	35.7937
Opportunity Cost Of Unpaid Labor	$	4.9124	4.9285	4.9446	4.9608	4.9770	4.9933	5.0097	5.0261	5.0425	5.0590	5.0756	5.0922	60.0215
Compound Int (Labor) To Valuation Month	$	0.6589	0.5987	0.5386	0.4785	0.4185	0.3586	0.2987	0.2389	0.1791	0.1193	0.0596	0.0000	3.9475
Capital Recovery Of Livestock Inv	$													0.0000
Capital Recovery Of Machinery Inv	$													17.8894
Capital Recovery of Bldg Inv	$													23.1390
Taxes & Insurance	$													3.9999
General Farm Overhead														17.2135
Total Allocated Overhead	$													162.0046
Overall Total Cost	$													577.6699

Table 13A.6B Expenses Per Month For 1992 Projected Costs & Returns For Heifer Production (13-24) months

ITEM	UNIT	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	ANNUAL
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		1	2	3	4	5	6	7	8	9	10	11	12	
Quantity Purchased														
Heifer Calf (Jan 1 purchase)	HD	0.0000												1.0000
Corn	bu	0.3300	0.3300	0.3300	0.3300	0.3300	0.3300	0.3300	0.3300	0.3400	0.3400	0.3400	0.3400	4.0000
Protein, Vit. & Min	cwt	0.0625	0.0625	0.0625	0.0625	0.0625	0.0625	0.0625	0.0625	0.0625	0.0625	0.0625	0.0625	0.7500
Alfalfa Hay	ton	0.1050	0.1050	0.1050	0.1050	0.1050	0.1050	0.1050	0.1050	0.1050	0.1050	0.1050	0.1050	1.2600
Alfalfa Haylage	ton	0.1175	0.1175	0.1175	0.1175	0.1175	0.1175	0.1175	0.1175	0.1175	0.1175	0.1175	0.1175	1.4100
Corn Silage	ton	0.1975	0.1975	0.1975	0.1975	0.1975	0.1975	0.1975	0.1975	0.1975	0.1975	0.1975	0.1975	2.3700
Milk Replacer	lbs													0.0000
Purchase Price														
Heifer Calf (Jan 1 Purchase)	$/HD	144.2308												144.2308
Corn	$/Bu	2.0258	2.0325	2.0391	2.0458	2.0525	2.0592	2.0660	2.0727	2.0795	2.0863	2.0931	2.1000	2.0627
Protein, Vit. & Min	$/cwt	14.6922	14.7403	14.7885	14.8369	14.8855	14.9342	14.9831	15.0322	15.0814	15.1308	15.1803	15.2300	14.9596
Alfalfa Hay	$/Ton	77.1749	77.4276	77.6810	77.9353	78.1905	78.4465	78.7033	78.9609	79.2194	79.4788	79.7390	80.0000	78.5798
Alfalfa Haylage	$/Ton	72.3515	72.5883	72.8260	73.0644	73.3036	73.5436	73.7843	74.0259	74.2682	74.5113	74.7553	75.0000	73.6685
Corn Silage	$/Ton	16.1103	16.1630	16.2159	16.2690	16.3223	16.3757	16.4293	16.4831	16.5371	16.5912	16.6455	16.7000	16.4035
Milk Replacer	$/lbs	0.7910	0.7936	0.7962	0.7988	0.8015	0.8041	0.8067	0.8093	0.8120	0.8147	0.8173	0.8200	0.8054
Operating Costs														
Replacement Heifer	$	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Corn	$	0.6685	0.6707	0.6729	0.6751	0.6773	0.6795	0.6818	0.6840	0.7070	0.7093	0.7117	0.7140	8.2520
Protein, Vit. & Min	$	0.9183	0.9213	0.9243	0.9273	0.9303	0.9334	0.9364	0.9395	0.9426	0.9457	0.9488	0.9519	11.2197
Alfalfa Hay	$	8.1034	8.1299	8.1565	8.1832	8.2100	8.2369	8.2638	8.2909	8.3180	8.3453	8.3726	8.4000	99.0105
Alfalfa Haylage	$	8.5013	8.5291	8.5571	8.5851	8.6132	8.6414	8.6697	8.6980	8.7265	8.7551	8.7837	8.8125	103.8726
Corn Silage	$	3.1818	3.1922	3.2026	3.2131	3.2236	3.2342	3.2448	3.2554	3.2661	3.2768	3.2875	3.2983	38.8764
Milk Replacer	$	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Breeding	$	0.0000	0.0000	45.4434	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	45.4434
Veterinary & Medicine	$	0.6000	0.6000	0.6000	0.6000	0.6000	0.6000	0.6000	0.6000	0.6000	0.6000	0.6000	0.6000	7.2000
Supplies	$	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	12.0000
Fuel & Oil	$	0.3766	0.3778	0.3790	0.3803	0.3815	0.3828	0.3840	0.3853	0.3865	0.3878	0.3891	0.3904	4.6011
Bedding	$	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	12.0000
Repairs (nominal $)	$	2.6986	2.7074	2.7163	2.7252	2.7341	2.7431	2.7520	2.7611	2.7701	2.7792	2.7883	2.7974	32.9727
Total (excluding dairy heifer)	$	27.0484	27.1284	72.6521	27.2893	27.3701	27.4512	27.5326	27.6142	27.7169	27.7991	27.8816	25.1670	372.6510
Total Operating Costs	$	27.0484	27.1284	72.6521	27.2893	27.3701	27.4512	27.5326	27.6142	27.7169	27.7991	27.8816	27.9644	375.4484
Annual Nominal Int Rate	Decimal	0.0920	0.0920	0.0920	0.0920	0.0920	0.0920	0.0920	0.0920	0.0920	0.0920	0.0920	0.0920	
Monthly Compound Nominal Int Rate	Decimal	0.0074	0.0074	0.0074	0.0074	0.0074	0.0074	0.0074	0.0074	0.0074	0.0074	0.0074	0.0074	
Valuation Month(Dec=12, etc)	Integer	12	12	12	12	12	12	12	12	12	12	12	12	
Valuation Month-Current Month	Integer	11	10	9	8	7	6	5	4	3	2	1	0	
Compound Int To Valuation Month (no heifers)	$	2.2726	2.0644	4.9575	1.6491	1.4419	1.2350	1.0284	0.8221	0.6166	0.4108	0.2052	0.0000	16.7036
Compound Int To Valuation Month (inc heifers)	$	2.2726	2.0644	4.9575	1.6491	1.4419	1.2350	1.0284	0.8221	0.6166	0.4108	0.2052	0.0000	16.7036
Allocated Overhead														
Hired Labor	$	2.9295	2.9391	2.9487	2.9584	2.9680	2.9778	2.9875	2.9973	3.0071	3.0169	3.0268	3.0367	35.7937
Opportunity Cost Of Unpaid Labor	$	4.9124	4.9285	4.9446	4.9608	4.9770	4.9933	5.0097	5.0261	5.0425	5.0590	5.0756	5.0922	60.0215
Compound Int (Labor) To Valuation Month	$	0.6589	0.5987	0.5386	0.4785	0.4185	0.3586	0.2987	0.2389	0.1791	0.1193	0.0596	0.0000	3.9475
Capital Recovery Of Livestock Inv	$													0.0000
Capital Recovery Of Machinery Inv	$													17.8894
Capital Recovery of Bldg Inv	$													23.1390
Taxes & Insurance	$													3.9999
General Farm Overhead	$													17.2135
Total Allocated Overhead	$													162.0046
Overall Total Cost	$													554.1565

Table 13A.7 Expenses Per Month For Projected 1992 Costs & Returns For Heifer Production (current value method)

ITEM	UNIT	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	ANNUAL
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		1.0000	2.0000	3.0000	4.0000	5.0000	6.0000	7.0000	8.0000	9.0000	10.0000	11.0000	12.0000	
Quantity Purchased														
Heifer Calf (Jan 1 purchase)	Bu													
Corn	cwt	1.7500	1.7500	1.7500	1.7500	1.7500	1.7500	1.7500	1.7500	1.7500	1.7500	1.7500	1.7500	21.0000
Protein, Vit. & Min	ton	0.2292	0.2292	0.2292	0.2292	0.2292	0.2292	0.2292	0.2292	0.2292	0.2292	0.2292	0.2292	2.7500
Alfalfa Hay	ton	0.1373	0.1373	0.1373	0.1373	0.1373	0.1373	0.1373	0.1373	0.1373	0.1373	0.1373	0.1373	1.6480
Alfalfa Haylage	ton	0.1533	0.1533	0.1533	0.1533	0.1533	0.1533	0.1533	0.1533	0.1533	0.1533	0.1533	0.1533	1.8400
Corn Silage	lbs	0.2586	0.2586	0.2586	0.2586	0.2586	0.2586	0.2586	0.2586	0.2586	0.2586	0.2586	0.2586	3.1030
Milk Replacer	cwt	3.3333	3.3333	3.3333	3.3333	3.3333	3.3333	3.3333	3.3333	3.3333	3.3333	3.3333	3.3333	40.0000
Purchase Price														
Heifer Calf (Jan 1 Purchase)	$/Bu	2.0258	2.0325	2.0391	2.0458	2.0525	2.0592	2.0660	2.0727	2.0795	2.0863	2.0931	2.1000	2.0627
Corn	$/cwt	14.6922	14.7403	14.7885	14.8369	14.8855	14.9342	14.9831	15.0322	15.0814	15.1308	15.1803	15.2300	14.9596
Protein, Vit. & Min	$/Ton	77.1749	77.4276	77.6810	77.9353	78.1905	78.4465	78.7033	78.9609	79.2194	79.4788	79.7390	80.0000	78.5798
Alfalfa Hay	$/Ton	72.3515	72.5883	72.8260	73.0644	73.3036	73.5436	73.7843	74.0259	74.2682	74.5113	74.7553	75.0000	73.6685
Alfalfa Haylage	$/Ton	16.1103	16.1630	16.2159	16.2690	16.3223	16.3757	16.4293	16.4831	16.5371	16.5912	16.6455	16.7000	16.4035
Corn Silage	$/lbs	0.7910	0.7936	0.7962	0.7988	0.8015	0.8041	0.8067	0.8093	0.8120	0.8147	0.8173	0.8200	0.8054
Milk Replacer	$/cwt	0.4698	0.4714	0.4729	0.4745	0.4760	0.4776	0.4792	0.4807	0.4823	0.4839	0.4855	0.4870	0.4784
Operating Costs														
Replacement Heifer	$	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Corn	$	25.7113	25.7955	25.8799	25.9646	26.0496	26.1349	26.2205	26.3063	26.3924	26.4788	26.5655	26.6525	314.1520
Protein, Vit. & Min	$	17.6859	17.7438	17.8019	17.8602	17.9187	17.9773	18.0362	18.0952	18.1545	18.2139	18.2735	18.3333	216.0943
Alfalfa Hay	$	9.9363	9.9688	10.0014	10.0342	10.0670	10.1000	10.1330	10.1662	10.1995	10.2329	10.2664	10.3000	121.4057
Alfalfa Haylage	$	2.4702	2.4783	2.4864	2.4946	2.5027	2.5109	2.5192	2.5274	2.5357	2.5440	2.5523	2.5607	30.1825
Corn Silage	$	0.2046	0.2052	0.2059	0.2066	0.2072	0.2079	0.2086	0.2093	0.2100	0.2107	0.2113	0.2120	2.4993
Milk Replacer	$	1.5662	1.5713	1.5764	1.5816	1.5868	1.5920	1.5972	1.6024	1.6076	1.6129	1.6182	1.6235	19.1360
Breeding	$	3.7192	3.7314	3.7436	3.7559	3.7682	3.7805	3.7929	3.8053	3.8178	3.8303	3.8428	3.8554	45.4434
Veterinary & Medicine	$	1.6532	1.6587	1.6641	1.6695	1.6750	1.6805	1.6860	1.6915	1.6970	1.7026	1.7082	1.7138	20.2000
Supplies	$	1.2186	1.2226	1.2266	1.2307	1.2347	1.2387	1.2428	1.2469	1.2509	1.2550	1.2591	1.2633	14.8900
Fuel & Oil	$	0.7531	0.7556	0.7581	0.7606	0.7631	0.7656	0.7681	0.7706	0.7731	0.7756	0.7782	0.7807	9.2022
Bedding	$	2.9464	2.9560	2.9657	2.9754	2.9851	2.9949	3.0047	3.0146	3.0244	3.0343	3.0443	3.0542	36.0000
Repairs (nominal $)	$	5.3972	5.4149	5.4326	5.4504	5.4682	5.4861	5.5041	5.5221	5.5402	5.5583	5.5765	5.5948	65.9455
Total Operating Costs	$	73.2623	73.5021	73.7428	73.9842	74.2264	74.4694	74.7132	74.9578	75.2031	75.4493	75.6963	75.9442	895.1510
Annual Nominal Int Rate	Decimal	0.0920	0.0920	0.0920	0.0920	0.0920	0.0920	0.0920	0.0920	0.0920	0.0920	0.0920	0.0920	
Monthly Compound Nominal Int Rate	Decimal	0.0074	0.0074	0.0074	0.0074	0.0074	0.0074	0.0074	0.0074	0.0074	0.0074	0.0074	0.0074	
Valuation Month(Dec=12, etc)	Integer	12.0000	12.0000	12.0000	12.0000	12.0000	12.0000	12.0000	12.0000	12.0000	12.0000	12.0000	12.0000	
Valuation Month-Current Month	Integer	11.0000	10.0000	9.0000	8.0000	7.0000	6.0000	5.0000	4.0000	3.0000	2.0000	1.0000	0.0000	
Compound Int To Valuation Month	$	6.1555	5.5934	5.0319	4.4708	3.9103	3.3502	2.7907	2.2316	1.6730	1.1149	0.5572	0.0000	36.8795
Allocated Overhead														
Hired Labor	$	5.8590	5.8782	5.8974	5.9167	5.9361	5.9555	5.9750	5.9946	6.0142	6.0339	6.0536	6.0734	71.5875
Opportunity Cost Of Unpaid Labor	$	9.8247	9.8569	9.8892	9.9216	9.9540	9.9866	10.0193	10.0521	10.0850	10.1180	10.1512	10.1844	120.0431
Compound Int (Labor) To Valuation Month	$	1.3178	1.1974	1.0772	0.9571	0.8371	0.7172	0.5974	0.4777	0.3582	0.2387	0.1193	0.0000	7.8950
Capital Recovery Of Livestock Inv	$													0.0000
Capital Recovery Of Machinery Inv	$													35.7788
Capital recovery of Bldg Inv	$													46.2780
Taxes & Insurance	$													7.9998
General Farm Overhead	$													34.4269
Total Allocated Overhead	$													324.0092
Overall Total Cost	$													1265.1602

TABLE 13A.7 1992 Projected Costs for Production of a Dairy Heifer (current value method) Notes

The estimates in Tables 13A.5AB and 13A.6AB consider the costs of raising one dairy heifer from birth to one year of age (A tables) and from 1 year of age to freshening (B tables). The costs are allocated across months assuming the calf is born at the beginning of the first year and freshens at the end of the second year. Expenses follow a pattern consistent with the growth of the calf over the two-year period.

Current value cost estimates assume that the operation is in a long-run equilibrium and the number of cows, calves, and yearlings does not change. In the Dairyman operation, 89 cows and 71.2 heifers in various stages of growth are always in inventory. Thus, in computing current cost estimates, the expenses for a heifer over both years are added and then divided equally between months with the idea that the same percentage of calves are born and cows culled each month. The data in Table 13A.7 come from adding the item totals in Tables 13.6A and 13.6B and then dividing them equally over the 12 months of the year.

Because the replacement rate for Ben and Bev's operation is 40%, 40% of these costs are used in the current value method in Table 13A.4. In order to make all the calculations as clear as possible for this example estimate, it was assumed that there is no death loss in raising the heifers from birth to freshening. A more appropriate approach would be to divide the cost per heifer by one minus the death percentage over the two years. This was not done, simply to ease the discussion of the numbers in the tables.

Table 13A.8 Prices used in Dairy Farm Example

Real Interest	0.05													
Inflation	0.04													
Nominal Interest	0.092													
Monthly Inflation	0.0032737													
	Real Price	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	
Real Prices	**for Year**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**July**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Average**
Milk	12.5000	12.5000	12.5000	12.5000	12.5000	12.5000	12.5000	12.5000	12.5000	12.5000	12.5000	12.5000	12.5000	12.5000
Cull Cows	46.4000	46.4000	46.4000	46.4000	46.4000	46.4000	46.4000	46.4000	46.4000	46.4000	46.4000	46.4000	46.4000	46.4000
Bull Calves	125.0000	125.0000	125.0000	125.0000	125.0000	125.0000	125.0000	125.0000	125.0000	125.0000	125.0000	125.0000	125.0000	125.0000
Heifer Calves	150.0000	150.0000	150.0000	150.0000	150.0000	150.0000	150.0000	150.0000	150.0000	150.0000	150.0000	150.0000	150.0000	150.0000
Replacement Heifers (market)	1050.000	1050.000	1050.000	1050.000	1050.000	1050.000	1050.000	1050.000	1050.000	1050.000	1050.000	1050.000	1050.000	1050.000
Replacement Heifers (raised)	1160.710	1160.710	1160.710	1160.710	1160.710	1160.710	1160.710	1160.710	1160.710	1160.710	1160.710	1160.710	1160.710	1160.710
Corn	2.1000	2.1000	2.1000	2.1000	2.1000	2.1000	2.1000	2.1000	2.1000	2.1000	2.1000	2.1000	2.1000	2.1000
Pre-mix	15.2300	15.2300	15.2300	15.2300	15.2300	15.2300	15.2300	15.2300	15.2300	15.2300	15.2300	15.2300	15.2300	15.2300
Alfalfa Hay	80.0000	80.0000	80.0000	80.0000	80.0000	80.0000	80.0000	80.0000	80.0000	80.0000	80.0000	80.0000	80.0000	80.0000
Alfalfa Haylage	75.0000	75.0000	75.0000	75.0000	75.0000	75.0000	75.0000	75.0000	75.0000	75.0000	75.0000	75.0000	75.0000	75.0000
Corn Silage	16.7000	16.7000	16.7000	16.7000	16.7000	16.7000	16.7000	16.7000	16.7000	16.7000	16.7000	16.7000	16.7000	16.7000
Marketing	0.4870	0.4870	0.4870	0.4870	0.4870	0.4870	0.4870	0.4870	0.4870	0.4870	0.4870	0.4870	0.4870	0.4870
Breeding	3.9705	3.9705	3.9705	3.9705	3.9705	3.9705	3.9705	3.9705	3.9705	3.9705	3.9705	3.9705	3.9705	3.9705
Veterinary & Medicine	5.4740	5.4740	5.4740	5.4740	5.4740	5.4740	5.4740	5.4740	5.4740	5.4740	5.4740	5.4740	5.4740	5.4740
Supplies	13.2350	13.2350	13.2350	13.2350	13.2350	13.2350	13.2350	13.2350	13.2350	13.2350	13.2350	13.2350	13.2350	13.2350
Fuel & Oil (Cows)	2.2554	2.2554	2.2554	2.2554	2.2554	2.2554	2.2554	2.2554	2.2554	2.2554	2.2554	2.2554	2.2554	2.2554
Fuel & Oil (Heifers)	0.3904	0.3904	0.3904	0.3904	0.3904	0.3904	0.3904	0.3904	0.3904	0.3904	0.3904	0.3904	0.3904	0.3904
Seasonal Price Index		**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**July**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Average**
Milk		103.0000	101.8000	100.0000	98.4000	96.8000	95.7000	96.4000	97.7000	100.3000	102.7000	103.8000	103.3000	99.9917
Cull Cows		96.0000	103.1000	105.5000	104.3000	104.0000	101.5000	100.5000	101.2000	100.5000	97.8000	93.1000	92.4000	99.9917
Bull Calves		100.0000	100.0000	100.0000	100.0000	100.0000	100.0000	100.0000	100.0000	100.0000	100.0000	100.0000	100.0000	100.0000
Heifer Calves		100.0000	100.0000	100.0000	100.0000	100.0000	100.0000	100.0000	100.0000	100.0000	100.0000	100.0000	100.0000	100.0000
Replacement Heifers (market)		100.0000	100.0000	100.0000	100.0000	100.0000	100.0000	100.0000	100.0000	100.0000	100.0000	100.0000	100.0000	100.0000
Replacement Heifers (raised)		100.0000	100.0000	100.0000	100.0000	100.0000	100.0000	100.0000	100.0000	100.0000	100.0000	100.0000	100.0000	100.0000
Corn		100.0000	100.0000	100.0000	100.0000	100.0000	100.0000	100.0000	100.0000	100.0000	100.0000	100.0000	100.0000	100.0000
Pre-mix		100.0000	100.0000	100.0000	100.0000	100.0000	100.0000	100.0000	100.0000	100.0000	100.0000	100.0000	100.0000	100.0000
Alfalfa Hay		100.0000	100.0000	100.0000	100.0000	100.0000	100.0000	100.0000	100.0000	100.0000	100.0000	100.0000	100.0000	100.0000
Alfalfa Haylage		100.0000	100.0000	100.0000	100.0000	100.0000	100.0000	100.0000	100.0000	100.0000	100.0000	100.0000	100.0000	100.0000
Corn Silage		100.0000	100.0000	100.0000	100.0000	100.0000	100.0000	100.0000	100.0000	100.0000	100.0000	100.0000	100.0000	100.0000
Marketing		100.0000	100.0000	100.0000	100.0000	100.0000	100.0000	100.0000	100.0000	100.0000	100.0000	100.0000	100.0000	100.0000
Breeding		100.0000	100.0000	100.0000	100.0000	100.0000	100.0000	100.0000	100.0000	100.0000	100.0000	100.0000	100.0000	100.0000
Veterinary & Medicine		100.0000	100.0000	100.0000	100.0000	100.0000	100.0000	100.0000	100.0000	100.0000	100.0000	100.0000	100.0000	100.0000
Supplies		100.0000	100.0000	100.0000	100.0000	100.0000	100.0000	100.0000	100.0000	100.0000	100.0000	100.0000	100.0000	100.0000
Fuel & Oil (Cows)		100.0000	100.0000	100.0000	100.0000	100.0000	100.0000	100.0000	100.0000	100.0000	100.0000	100.0000	100.0000	100.0000
Fuel & Oil (Heifers)		100.0000	100.0000	100.0000	100.0000	100.0000	100.0000	100.0000	100.0000	100.0000	100.0000	100.0000	100.0000	100.0000

Table 13A.8 Prices used in Dairy Farm Example

Seasonally Adjusted Real Prices	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**July**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Average**
Milk	12.8750	12.7250	12.5000	12.3000	12.1000	11.9625	12.0500	12.2125	12.5375	12.8375	12.9750	12.9125	12.4990
Cull Cows	44.5440	47.8384	48.9520	48.3952	48.2560	47.0960	46.6320	46.9568	46.6320	45.3792	43.1984	42.8736	46.3961
Bull Calves	125.0000	125.0000	125.0000	125.0000	125.0000	125.0000	125.0000	125.0000	125.0000	125.0000	125.0000	125.0000	125.0000
Heifer Calves	150.0000	150.0000	150.0000	150.0000	150.0000	150.0000	150.0000	150.0000	150.0000	150.0000	150.0000	150.0000	150.0000
Replacement Heifers (market)	1050.000	1050.000	1050.000	1050.000	1050.000	1050.000	1050.000	1050.000	1050.000	1050.000	1050.000	1050.000	1050.000
Replacement Heifers (raised)	1160.710	1160.710	1160.710	1160.710	1160.710	1160.710	1160.710	1160.710	1160.710	1160.710	1160.710	1160.710	1160.710
Corn	2.1000	2.1000	2.1000	2.1000	2.1000	2.1000	2.1000	2.1000	2.1000	2.1000	2.1000	2.1000	2.1000
Pre-mix	15.2300	15.2300	15.2300	15.2300	15.2300	15.2300	15.2300	15.2300	15.2300	15.2300	15.2300	15.2300	15.2300
Alfalfa Hay	80.0000	80.0000	80.0000	80.0000	80.0000	80.0000	80.0000	80.0000	80.0000	80.0000	80.0000	80.0000	80.0000
Alfalfa Haylage	75.0000	75.0000	75.0000	75.0000	75.0000	75.0000	75.0000	75.0000	75.0000	75.0000	75.0000	75.0000	75.0000
Corn Silage	16.7000	16.7000	16.7000	16.7000	16.7000	16.7000	16.7000	16.7000	16.7000	16.7000	16.7000	16.7000	16.7000
Marketing	0.4870	0.4870	0.4870	0.4870	0.4870	0.4870	0.4870	0.4870	0.4870	0.4870	0.4870	0.4870	0.4870
Breeding	3.9705	3.9705	3.9705	3.9705	3.9705	3.9705	3.9705	3.9705	3.9705	3.9705	3.9705	3.9705	3.9705
Veterinary & Medicine	5.4740	5.4740	5.4740	5.4740	5.4740	5.4740	5.4740	5.4740	5.4740	5.4740	5.4740	5.4740	5.4740
Supplies	13.2350	13.2350	13.2350	13.2350	13.2350	13.2350	13.2350	13.2350	13.2350	13.2350	13.2350	13.2350	13.2350
Fuel & Oil (Cows)	2.2554	2.2554	2.2554	2.2554	2.2554	2.2554	2.2554	2.2554	2.2554	2.2554	2.2554	2.2554	2.2554
Fuel & Oil (Heifers)	0.3904	0.3904	0.3904	0.3904	0.3904	0.3904	0.3904	0.3904	0.3904	0.3904	0.3904	0.3904	0.3904
Seasonally Adjusted Nominal Prices	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**July**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Average**
Milk	12.42	12.32	12.14	11.98	11.83	11.73	11.85	12.05	12.42	12.75	12.93	12.91	12.28
Cull Cows	42.97	46.30	47.53	47.15	47.16	46.18	45.88	46.35	46.18	45.08	43.06	42.87	45.56
Bull Calves	120.59	120.98	121.38	121.77	122.17	122.57	122.97	123.38	123.78	124.19	124.59	125.00	122.78
Heifer Calves	144.70	145.18	145.65	146.13	146.61	147.09	147.57	148.05	148.54	149.02	149.51	150.00	147.34
Replacement Heifers (market)	1012.921	1016.237	1019.564	1022.901	1026.250	1029.610	1032.980	1036.362	1039.755	1043.159	1046.574	1050.000	1031.359
Replacement Heifers (raised)	1119.721	1123.387	1127.064	1130.754	1134.456	1138.170	1141.896	1145.634	1149.385	1153.147	1156.922	1160.710	1140.104
Corn	2.03	2.03	2.04	2.05	2.05	2.06	2.07	2.07	2.08	2.09	2.09	2.10	2.06
Pre-mix	14.69	14.74	14.79	14.84	14.89	14.93	14.98	15.03	15.08	15.13	15.18	15.23	14.96
Alfalfa Hay	77.17	77.43	77.68	77.94	78.19	78.45	78.70	78.96	79.22	79.48	79.74	80.00	78.58
Alfalfa Haylage	72.35	72.59	72.83	73.06	73.30	73.54	73.78	74.03	74.27	74.51	74.76	75.00	73.67
Corn Silage	16.11	16.16	16.22	16.27	16.32	16.38	16.43	16.48	16.54	16.59	16.65	16.70	16.40
Marketing	0.4698	0.4714	0.4729	0.4745	0.4760	0.4776	0.4792	0.4807	0.4823	0.4839	0.4855	0.4870	0.4784
Breeding	3.8303	3.8428	3.8554	3.8680	3.8807	3.8934	3.9061	3.9189	3.9317	3.9446	3.9575	3.9705	3.9000
Veterinary & Medicine	5.2807	5.2980	5.3153	5.3327	5.3502	5.3677	5.3853	5.4029	5.4206	5.4383	5.4561	5.4740	5.3768
Supplies	12.7676	12.8094	12.8513	12.8934	12.9356	12.9779	13.0204	13.0631	13.1058	13.1487	13.1918	13.2350	13.0000
Fuel & Oil (Cows)	2.1757	2.1829	2.1900	2.1972	2.2044	2.2116	2.2188	2.2261	2.2334	2.2407	2.2480	2.2554	2.2154
Fuel & Oil (Heifers)	0.3766	0.3778	0.3790	0.3803	0.3815	0.3828	0.3840	0.3853	0.3865	0.3878	0.3891	0.3904	0.3834

APPENDIX 13B

PROCEDURES TO ENHANCE THE DATA MANAGEMENT PROCESS AND DATA SHARING

Greater reliance on computer technology will be needed to achieve editing, verifying, updating, and sharing objectives for CAR, particularly when addressing data management procedures and the need to more freely exchange data. Computer developments will involve the use of standardized procedures that are heavily dependent upon database and modelbase systems. The increased availability and use of object oriented database systems make the proposed CAR recommendations even more promising because data management procedures can be mixed with calculation procedures (Rahn and Harsh).

To achieve some degree of standardization of CAR, a data entity-relationship model should be employed. An entity is an object or concept of interest about which data can be stored. Each entity has a set of attributes that provides information regarding the entity. A relationship is a connection between two entities. This approach is illustrated in Table 13B.1 (and in discussion of CAR footnotes and data attribute ideas in the section of this chapter entitled Formats for CAR Summaries and Supporting Tables and Footnotes).

A code is attached to each of the entities in Table 13B.1. This code is a pointer to additional information regarding the data entity. The additional information can be textual, a calculation process, or another data entity. For example, the cotton CAR has the code B1. This is a pointer to a database entity that provides additional information (e.g., region that the budget relates to, farm characteristics, time period involved, data collection methods used, production technologies employed, and so forth). Likewise, the price for cotton seed has the assigned code P111. This data entity may contain additional details regarding the price's source, last date price was updated, units used to state price, and other attributes related to this price data entity.

The quantity related to cotton seed has the code M314. This is the pointer to the procedure (calculation method) used to determine the seed quantity. The method indicates that the seed quantity has been adjusted to reflect the need to replant in 6 out of 10 years. A procedure (M19) is also used with the herbicide quality. This procedure involves a "representative" herbicide program that results in an expected cost per acre.

The use of database and modelbase procedures has many advantages including maintenance ease, better documentation of data used in the budget, and the ability to exchange data in electronic form. However, to insure that database procedures meet the intended objectives, extensive efforts will be needed in designing the various database structures that comprise the system. Also, efforts will be needed to develop standardized procedures for doing the many calculations (e.g., weighing returns and costs) involved in developing the CAR.

Illustration of Data Management Procedures

To better illustrate the potential and functional characteristics of database and modelbase procedures, and to also indicate that the additional efforts needed to use these approaches are modest, a prototype example will be utilized. The prototype example is only partially completed because it has been prepared only for illustrative purposes. A finalized design can and should be done by a professional group appointed to further develop the structure for a comprehensive database and modelbase CAR package.

Four files are required to make the database system functional (see Table 13B.2). The first file (ENTRPRSE) (see Table 13B.3) contains documentation details regarding the CAR. It indicates the enterprise on which the analysis was done and other critical information with respect to the development (e.g., location of analysis, date, assumed level of management, technologies employed, etc.). This file will be the basis for an inventory of existing CAR discussed in the text of the report.

To allow for nationwide sharing of data, the structure of this file needs to be carefully designed. If a national level ENTRPRSE database is developed, new records can be added as new CAR studies are completed. Thus, those wanting to know the existence of other CAR studies related to selected enterprises can then query the national database.

All files related to a specific CAR enterprise study would be stored in a unique directory as defined in the "DATA_DIR" column of the "ENTRPRSE" file. Also, a budget can be a virtual budget. This will allow the creation of a new budget by using a weighted confirmation of other budgets (e.g., a wheat and summer fallow rotation).

A second file contains the price data used in the CAR study. This file has details (attributes) with respect to the prices used in the analysis. In addition to the price value, it provides information with respect to source of the price (e.g., a farmer or supplier survey), date of price, price location, and so forth. A master price file might be used because several enterprises might share a common set of price data (e.g., cost of urea fertilizer that is used on several crops) and the individual CAR price file could reference the master price file.

The third file (C_R_TRN) contains the basic data related to the CARs. The suggested database file structure is shown in Table 13B.4. The structure of the data closely parallels a financial transaction such as recorded in records systems. To make the data shareable, it will be necessary to use standardized codes for items considered in the CAR study. A possible coding system for these items is shown in Table 13B.5. Each return or cost requires a separate record in the database file. The keeping of nonaggregated data is strongly suggested. This would involve adding a record for each return or cost. The modelbase will be used to aggregate the data in (C_R_TRN) to a higher level of summarization. The greater the detail contained in this file, the better the data can be shared with others.

The last file (NOTES) is used to store supporting notes regarding the CAR analysis. Each price or quantity specified as part of a record in the CAR basic data file could have a supporting note attached. This file could be part of the database file as memo columns (thus not really a separate file), a separate database file, or a word processing file with the note clearly labeled (e.g., N 284 for Note No. 284, which might be attached to a quantity amount). Notes can be used to indicate how values are calculated (e.g., 6 out of 10 years there is a need to replant and thus the seed amount has been adjusted accordingly).

Storing data in a database certainly leads to a more standardized approach and thus enhances the possibilities for sharing data. However, to gain the full advantages of using database and modelbase procedure, the ability to extract and manipulate data is equally important; thus, there is a need for modelbase tools. These tools can either be developed using higher-level languages (e.g., FORTRAN or C) that have access to a library of routines that can create, access, and update the databases discussed above or special modelbase/database interface packages such as the DAX Package (Data Access and eXchange Package).

To illustrate the usefulness of linking database and modelbase, the DAX Package will be used. A DAX set of commands has been developed to generate reports (only the variable expense proportion is illustrated) along the lines suggested in this chapter. DAX commands that have been developed to generate the desired reports from the CAR data are contained in the data file ENTRPRSE. Applying these commands to the file results in the file contained in Figure 13B.1.

It is also noted in the section of this chapter entitled Formats for CAR Summaries and Supporting Tables and Footnotes that different users of the CAR data may desire different report structures. Because the basic data are contained in the database, the modelbase (e.g., DAX) can be designed to generate a wide variety of reports depending upon the needs of the user.

DETAILED REPORT:

```
Item Code | Description        | Unit |      Price |        Qty |       Value
-----------------------------------------------------------------------------
O01        Hybrid seed          BAG         70.0000        .3300       23.10
                                                                 ------------
         Subtotal for Seed                                              23.10

O0203      Urea                 POUND         .1100     100.0000       11.00
O0204      Anhydrous Amonia     POUND         .8750      80.0000       70.00
                                                                 ------------
         Subtotal for Fertilizer                                        81.00

O030201    2,4-D Amine L        PINT         1.2800       2.0000        2.56
O03020201  Atrazin, Aatrex, 4L  QUART        3.0470       1.5000        4.57
                                                                 ------------
         Subtotal for Pesticides                                         7.13


                                                                 ------------
         Grand Total (Operating):                                      111.23

=============================================================================
```

SUMMARY REPORT:

```
Non-detailed summary:

Subtotal for Seed                      23.10
Subtotal for Fertilizer                81.00
Subtotal for Pesticides                 7.13
                                ____________
Grand total:                          111.23
```

FIGURE 13B.1 CAR Reports Generated by the DAX Package

TABLE 13B.1 CAR Budget Using Database Procedures

Cotton Budget -- Option I (B1)				
Operating Inputs	Units	Price ($)	Quantity	Value ($)
Cotton Seed	Lbs.	0.6 (P111)	28.8 (M314)	17.28
Pre-Merge Herbicide	Acre	6.75 (M19)	1.00 (Q100)	6.75
--				
etc.				

TABLE 13B.2 Suggested Database for CAR

Files	Function
ENTRPRSE	Provide details regarding the enterprise for which the costs and returns relate.
PRICE	This file contains details regarding the prices used in the enterprise CARs.
C_R_TRN	This file, (a unique one for each CAR data) contains the CAR data for a particular CAR study.
NOTES	This file (a unique one for each CAR data set) contains the back-up notes regarding the various costs and returns in the CAR data set. It can be a database file or a referenced word processing file, or fields of a database management program.

TABLE 13B.3 Possible Database Structure for Enterprise Definition

Filename: ENTRPRSE				
Column Name	Column Description	Column Type	Std Code[a]	Importance[b]
ENTR_CD	Enterprise Code	C20	Y	H
ENTR_NM	Enterprise Name	C40		H
DATA_DIR	Data Directory to Store Data	C80		
TIME_SCOPE	Historic or Projected	C1	Y	H
TYPE	Current or Normalized	C1	Y	H
VARIETY	Variety or Type	C30		
CNTCT_PER	Contact Person	C30		H
CNTCT_ADD1	Address 1 of Contact Person	C30		H
CNTCT_ADD2	Address 2 of Contact Person	C30		H
CNTCT_ADD3	Address 3 of Contact Person	C30		H
CNTCT_ADD4	Address 4 of Contact Person	C30		H
CNTCT-PH	Phone of Contact Person	C24		H
CNTCT_EM	E-mail of Contact Person	C30		H
CNTCT_FAX	FAX of Contact Person	C24		H
SOFTWARE	Software Used for Budget	Memo		R
COUNTRY	Country for CAR	C20	Y	H
REGION	Region or County for CAR	C20	Y	H
STATE_AREA	State or Province of County for CAR (Area by state for CAR)	C20	Y	H
DATE	Date CAR Prepared	D8	Y	H
PROD_STRT	Starting Period of Production	D8	Y	H
PROD_END	Ending Period of Production	D8	Y	H
ANAL_UNIT	Unit of Analysis (e.g., acre, sow, head, etc.)	C10	Y	H
YIELD_UNIT	Yield Unit (e.g., bushel, cwt.)	C5	Y	H
YIELD_LV	Yield/Production Level			H
YIELD_QLTY	Yield Quality	Memo		H
MNGT_LEVEL	Level of Management Assumed	Memo		R
FARM_SIZE	Size of Farm Assumed	C40		
SOIL_TYPE	Predominate Soil Type	C30		
TECH_TYPE	Technology Used	Memo		H
MARKETING	Marketing Used	Memo		
ROTATION	Rotation Plan Used	Memo		R

[a]If a code of "Y" is used, this means a standardized code should be used. This use of a standardized code is needed if easy sharing of data is to be accomplished.

[b]H = Highly recommend data, R = Recommended that data be supplied.

TABLE 13B.4 Possible Database Structure for Costs and Returns Transactions

Filename: C_R_TRN[a]

Column Name	Column Description	Column Type	Std Code[b]
ITEM_CODE	Code for Item Type	C9	Y
ITEM_DESC	Description of Item	C30	
DATE	Date of Transaction	D8	Y
OPERATION	Nature of Operation (e.g., planting)		
UNIT	Unit Used for Item	C5	
PRICE	Price of Item/Unit	N12.4	
PR_A_CODE	Attribute Code for Price (can link to PRICE file)	C8	
QUANTITY	Quantity of Item Used	N12.4	
QNTY_A_CODE	Attribute Code for Quantity	C8	
NOTE	Notes Related to Item	Memo	

a = each CAR analysis should have a unique directory in order to keep data of various analyses separated.

b = if a code of "Y" is used, this means a standardized code should be used. This use of a standardized code is needed if easy sharing of data is to be accomplished.

TABLE 13B.5 Possible Coding System for CAR

The codes used will have the following form:

TCCDDSSFF

LEVEL 1: (Type, 1 letter)

P = Primary Income
S = Secondary Income
O = Operating Expenses
F = Ownership Expenses
Q = Other Quantity Data[a]
A = Activity definition (e.g., planting)

LEVEL 2: (Classification, 2 digits)

For Primary Income:
01 = Dairy
02 = Beef
22 = Field Crops
23 = Fruit Crops
..
..
99 = Other Primary Income

For Operating Expenses:
01 = Seed
02 = Fertilizers
03 = Pesticides
..
..
..
99 = Other Operating Expenses

LEVEL 3: (Detail of Classification, 2 digits)

For Dairy:
01 = Milk
..
..
..
..
99 = Other Dairy

For Pesticides:
01 = Insecticide
02 = Herbicide
03 = Fungicide
..
..
99 = Other Pesticides

LEVEL 3: (Sub-Detail of Classification, 2 digits)

For Milk:
01 = Grade A
02 = Grade B
..
..
99 = Other Dairy

For Herbicide:
01 = 2:4-D Amine
02 = Atrazine
..
..
99 =

LEVEL 3: (Fine-Detail of Classification, 2 digits; this will be defined)

For Milk:
01 = Quota Market
02 = Non-Quota Market
..
99 = Other

For Herbicide:
01 = Antrex, 4C
02 = Antrex, 80W

a = This allows the entering of additional quantity data that are related to a transaction (e.g., 300 pounds of 12-24-16 supplies 36 pounds of N, 72 pounds of P_2O_5, and 48 pounds of K_2O).

CHAPTER 14

EXAMPLES OF COST AND RETURN ESTIMATES: UPPER MIDWEST DAIRY FARM

This chapter contains examples of cost and return (CAR) estimates for a Minnesota crop-livestock farm using the recommendations contained in this report. The same data was used in Chapter 13 to estimate the costs of production for the dairy enterprise on the farm.

UPPER MIDWEST DAIRY FARM

Farm Description

Ben Dairyman began farming with his father in 1974. He began buying into the business immediately and continued doing so as capital became available. By 1980 Ben and his wife, Bev, had taken over the operation of the business. On April 1,1980 they purchased the farm from Ben's parents. They had made a great deal of financial progress by the end of 1991. The data below were obtained from the summary of their farm records for 1991 and through a personal interview with Ben during early 1992.

The Dairyman family was composed of Ben and Bev, both 38 years old at the end of 1991, and 4 children. The children's ages were 5, 9, 12, and 14 at the close of 1991. Ben completed three years of a program leading to a bachelor's degree before returning to the farm. He was employed full time on the farm. Bev completed a B. A. in Liberal Arts. She had been employed off of the farm during the previous 17 years, with the exception of maternity leaves. She was working full time as an executive secretary for a firm in the local town (10 miles round trip) for an annual salary of $21,000. In addition, she helped with some of the office work and other overhead activities of the business.

Ben and Bev owned 356 acres of which 303 were cropped. In addition they paid cash rent to lease 55 acres and farmed another 47 acres under a crop-share arrangement. The number of acres of the crops they produced in 1991 are listed in Schedule 14.1. They produced a corn-soybean rotation on the better quality land. A rotation of corn, oats-alfalfa establishment, and three years of alfalfa production was produced on the remaining acreage. Cash rental rates in the area for the land suitable for the corn-soybean rotation were $85 per acre, while the rental for the lower quality land was $50. The landlord received one-third of the crop on the crop-shared land and did not share in the operating costs.

Ben participated in the feed grain program on the owned land. At the time these data were collected he planned to put an acreage equal to 5% of the corn base into the acreage reduction program (ARP) and collect the maximum deficiency payment during 1992. The rented land did not have a corn base.

Ben's dairy barn had space for 77 cows. The herd averaged 89 cows in 1991 (Schedule 14.2). In addition to milk and cull animals, he had been raising a few bulls from outstanding cows for sale as sires. The remaining bull calves were given to the full-time hired worker as nonmonetary compensation. The heifer calves were raised as herd replacements.

The operator's estimate of the labor use and the compensation paid during 1991 is given in Schedule 14.4. He expected it to be similar during 1992.

The buildings, improvements, machinery, and equipment at the close of 1991 are listed in Schedules 14.6 and 14.7. Many of these assets had been in use for a relatively long period. However, they were well maintained and very functional. In addition to the year of purchase and book value (remaining basis on the depreciation schedule), the operator provided estimates of the current market value and the years of useful life remaining.

Assumptions for Projected CARs

A projected CAR for the dairy herd on this farm is presented in Chapter 13. A brief version of the projected CAR is given in Table 13.2. A detailed CAR with related notes is presented in Table 13.3 and various appendix tables. Readers interested in a livestock example should refer to these tables.

The data sources and the assumptions made in preparing the 1992 projected CAR for corn and soybean are explained here. The machinery operations Ben planned to use during 1992 and the purchased inputs are listed in Schedules 14.5A, and 14.5B. The projected CAR are presented on an annual, per planted acre basis.

Gross Value of Production

The operator provided the average yield he expected to produce over the next five years. He assumed that any significant shortfall caused by hail, drought, flood, etc. would be made up for by crop insurance revenue. The expected production and revenue per acre is based on a projected yield of 130 bushels per acre. The owner has 151 acres of corn base on his own land. For corn, 0.05 of the base or 7.55 acres had to be placed in the acreage reduction program (ARP). The owner is eligible to receive deficiency payments on up to 85% of the corn base that is not placed in set-aside. Thus the deficiency payment applies to 80% of the corn base. The operator's ASCS program yield is 108 bushels per acre. The operator planned to plant 121 [(151)(0.80)] acres of corn on his owned land. Thus, the CAR for corn includes the cost and returns for 1 planted acre of corn and .0625 acres of ARP (7.55/121). The expected deficiency payment for 1992 was $0.48 per bushel. The actual average payment turned out to be $0.73 per bushel. The total expected deficiency payment is calculated as 151 ac x .80 x 108 bu x $.48 = $6,262.27. Dividing by 121 acres results in a deficiency payment of $51.75 per planted acre. The operator expected the cash price of corn on December 31, 1992 to be $2.15. This gives cash revenue of $279.50 per acre.

Fuel, Lube, and Repairs

The fuel, lube, and repair costs assume the power units are operated 10% longer than the time required for the operation. These three costs were calculated by multiplying the hours required for a given operation by the cost per hour and then summing over the machines listed in Schedule 14.5A. The specific operations required for corn production along with the costs of the operations are listed in Table 14A.1. Data

Chapter 14. Examples of Cost and Return Estimates: Upper Midwest Dairy Farm

Table 14.1 A Sample One-page CAR Summary for a Corn Budget

1992 Projected Costs and Returns for Corn Per Planted Acre on Owned Land, Detailed

Ben & Bev Dairyman Farm, Upper Midwest, USA (See Chapter 14 for a complete description of the farm)

Prepared by John Q. Taskforce, Department of Agricultural Economics, Anonymous State University, March 1992

	Item	Units	Quantity	Price	Value
	Gross Value Of Production:				
1	Corn (a)	Bu	130.0000	2.150	279.50
2	Deficiency Payment (b)	A c	1.0000	51.750	51.75
3	Interest on Receipts to December (c)			0.092	0.00
4	Total Revenue (d)				331.25
	Operating Costs				
5	Seed (e)	000	28.0000	0.882	24.70
6	Anhydrous Ammonia (f)	cwt	1.2000	9.400	11.28
7	Dry Fertilizer 8-32-16 (g)	cwt	1.0000	8.950	8.95
8	Zinc (g)	lb	1.0000	0.320	0.32
9	Extrazine (h)	lb	2.2000	3.790	8.34
10	2-4-D & Custom Application (i)	A c	1.0000	7.250	7.25
11	ARP Seed (j)	Bu	0.1000	3.000	0.30
12	Crop Insurance (k)	A c	1.0000	4.450	4.45
13	Anhydrous Applicator Rental (f)	A c	1.0000	0.500	0.50
14	Fuel & Lube (l)				6.60
15	Repairs (m)				5.40
16	Interest on Oper. Inputs to Dec (n)				4.55
17	Interest on Fuel & Lube to Dec (o)				0.22
18	Interest on Repairs to Dec (p)				0.17
19	Total Operating Costs (d)				83.02
	Allocated Overhead				
20	Hired Labor 1(q)	HR			9.41
21	Hired Labor 2(q)	HR			0.45
22	Opportunity Cost of Operator Labor (r)	HR			1.71
23	Opportunity Cost of Son's Labor (r)	HR			0.00
24	Total Implicit Interest on Labor (s)				0.38
25	Total Labor cost (s)				11.95
26	Capital Recovery of Mach & Eq Inv(t)				42.15
27	Opportunity Cost of Land (u)	A c	1.0625	85.000	90.31
28	Insurance (v)				0.00
29	General Farm Overhead (w)				9.73
30	Total Allocated Overhead (d)				166.09
31	Total Costs Listed (d)				249.11
32	Value Of Prod. Less Total Oper. Costs (d)				248.23
33	Value Of Prod. Less Total Costs Listed (d)				82.14

and assumptions used to estimate machinery costs are listed in Table 14A.2. The costs of operating various tractors and implements are contained in Table 14A.3, while the costs of performing various operations using tractors and implements are contained in Table 14A.4. The fuel consumption and repairs are estimated using list prices for machinery and horsepower given in Schedule 14.7 and the repair equations presented in Chapter 5 of this publication. All of the power units have a diesel engine. The price of diesel fuel delivered to the farm on January 1, 1992 is $0.90 per gallon.

Interest

Interest on operating inputs is based on cash costs and is calculated monthly until December 31 at an annual rate of 9.2%. This is based on a risk-free rate of 3%, a risk premium of 2% and an expected inflation rate of 4%. The risky real rate is then 5%. The monthly nominal interest rate is 0.7361% while the monthly inflation rate is 0.3274%.

Labor

The amounts of labor per cow in the projected CARs prepared in Chapter 13 were based on the hours used during 1991 as shown in Schedule 14.4. The amounts of labor for the crop enterprises by month are estimated using engineering equations for machinery with adjustments for downtime, fueling, travel, etc. The rates paid to hired workers during 1991 (Schedule 14.4) are adjusted forward to reflect inflation and used as the hired wage rates in the 1992 projections. The 1991 values are $9.47 per hour for worker 1 and $5.43 per hour for worker 2. The 1992 nominal averages are $9.845 per hour for hired worker 1 and $5.645 per hour for hired worker 2. The opportunity cost of unpaid labor for the operator was assumed to be $9.50 per hour in 1991. The wage rate of the second hired worker ($5.43 per hour) was used as an estimate of the opportunity cost of the son's labor in 1991. These 1991 wage rates were adjusted for inflation in 1992 giving 1992 nominal averages of $9.88 and $5.645 per hour. The allocation of tasks to the various labor types was based on history and Ben's best guess of who would likely perform the various operations. For example, Ben planned to plant and spray, but leave most other tasks to the hired help.

Capital Recovery

Capital recovery is based on the difference between the 1992 replacement purchase cost and the estimated salvage value at the end of the useful life using either the Cross-Perry (1995, 1996) or the ASAE remaining value equations. The capital recovery cost is computed using a real annuity that is then adjusted for inflation of 4% in the current period.

Other Overhead Costs

The general farm overhead costs are based on the allocations in Schedule 14.8 and the production of 154 acres of corn, 27 acres of corn silage, 30 acres of oats-alfalfa establishment, 83 acres of alfalfa, 102 acres of soybeans, and 7.55 acres of ARP. The insurance cost listed in Schedule 14.8 is insurance on the machinery and equipment. This cost is not allocated to the various enterprises in the projected CAR based on 1991 data but is computed directly in estimating machinery costs. The other overhead costs are allocated to the various crops based on the percentages in Schedule 14.8. The opportunity cost of land is the rental rate for the quality of land being used. Thus, neither the real estate taxes nor the interest on the real estate loan are allocated to the projected CAR for crops.

Table 14.2 A Sample Detailed CAR Summary for a Corn Budget

1992 Projected Costs and Returns for Corn Per Planted Acre on Owned Land, Detailed

Ben & Bev Dairyman Farm, Upper Midwest, USA (See Chapter 14 for a complete description of the farm)

Prepared by John Q. Taskforce, Department of Agricultural Economics, Anonymous State University, March 1992

	Item	Units	Quantity	Price	Month of Revenue/Expense	Value	Implicit interest
	Gross Value Of Production:						
1	Corn (a)	Bu	130.00	2.150	12	279.50	0.000
2	Deficiency Payment (b)	Ac	1.00	51.750	12	51.75	0.000
3	Interest on Receipts to December (c)			0.092		0.00	
4	Total Revenue (d)					331.25	
	Operating Costs						
5	Seed (e)	000	28.00	0.882	2	24.70	1.879
6	Anhydrous Ammonia (f)	cwt	1.20	9.400	-2	11.28	1.220
7	Dry Fertilizer 8-32-16 (g)	cwt	1.00	8.950	5	8.95	0.471
8	Zinc (g)	lb	1.00	0.320	5	0.32	0.017
9	Extrazine (h)	lb	2.20	3.790	5	8.34	0.439
10	2-4-D & Custom Application (i)	Ac	1.00	7.250	8	7.25	0.216
11	ARP Seed (j)	Bu	0.10	3.000	5	0.30	0.016
12	Crop Insurance (k)	Ac	1.00	4.450	5	4.45	0.234
13	Anhydrous Applicator Rental (f)	Ac	1.00	0.500	-2	0.50	0.054
14	Fuel & Lube (l)					6.60	0.222
15	Repairs (m)					5.40	
16	Interest on Oper. Inputs to Dec (n)					4.55	
17	Interest on Fuel & Lube to Dec (o)					0.22	
18	Interest on Repairs to Dec (p)					0.17	
19	Total Operating Costs (d)					83.02	
	Allocated Overhead						
20	Hired Labor 1(q)	HR	0.9510			9.41	
21	Hired Labor 2(q)	HR	0.0794			0.45	
22	Opportunity Cost of Operator Labor (r)	HR	0.1740			1.71	
23	Opportunity Cost of Son's Labor (r)	HR	0.0000				
24	Total Implicit Interest on Labor (s)					0.38	
25	Total Labor cost (s)					11.95	
26	Capital Recovery of Mach & Eq Inv(t)					42.15	
27	Opportunity Cost of Land (u)	Ac	1.0625	85.000		90.31	
28	Insurance (v)					0.00	
29	General Farm Overhead (w)					9.73	
30	Total Allocated Overhead (d)					166.09	
31	Total Costs Listed (d)					249.11	
32	Value Of Prod. Less Total Oper. Costs (d)					248.23	
33	Value Of Prod. Less Total Costs Listed (d)					82.14	

TABLE 14.2 1992 Projected Costs and Returns for Corn Per Planted Acre on Owned Land, Detailed Notes

---

[a] The corn is priced in December at $2.15 per bushel. The expected yield is 130 bushels per acre. This gives revenue of $279.5 [(2.15)(130)]. Because the revenue occurs at the end of the year, no interest accrues on receipts.

[b] The total expected deficiency payment is calculated as 151 ac. x 0.80 x 108 bu. x $0.48 where $0.48 is the expected deficiency payment per bushel. Dividing by 121 results in a deficiency payment of $51.75 per planted acre. This payment will actually accrue over an 18-month period but for the sake of simplicity in preparing this estimate, it was assumed that the entire payment occurred on December 31, 1992.

[c] Because all revenue payments were assumed to be received on December 31, 1992, there is no implicit interest on revenue. This line is the total of the implicit interest column in rows 1-2 of the table.

[d] Totals may not add due to rounding.

[e] Seed was planted at a rate of 28,000 kernels per acre. The price per 1,000 kernels was projected to be $0.882 for a total cost per acre of $24.70. Seed was purchased in February though it was not planted until May. The implicit interest was computed from February 28 until the end of the year. This gives an interest cost of

$$\begin{aligned} ic &= R(1+i)^{\frac{n}{12}} - R \\ &= (24.70)(1.092)^{\frac{10}{12}} - 24.70 \\ &= 1.879\,. \end{aligned}$$

[f] Anhydrous ammonia is applied in the November prior to planting. The operator uses his own tractor to apply the fertilizer but rents an applicator from the local cooperative. The cost of the applicator rental is included in line 13 and is $0.50 per acre. The cost of the use of the tractor is included in the lines on repair and capital recovery. Interest is charged for 14 months.

[g] Dry fertilizer (8-32-16) and zinc are applied at the time of planting (May) using an applicator attached to the corn planter.

[h] Extrazine (a corn herbicide) is applied in May using the operator's sprayer. Machinery and labor costs for spraying are included in lines 14, 15, 22, 24, and 26.

[i] 2-4 D was applied aerially in August. The cost listed includes the chemical and the custom aerial application.

TABLE 14.2 Detailed Notes (continued)

[j] Grass was planted on the acreage reduction program (ARP) acres (7.55) in May. The cost of the seed is listed in line 11, while the cost of labor and machinery are included in lines below.

[k] Crop insurance was $4.45 per acre. It assumed that the premiums are due in May.

[l] Fuel and lubrication was computed using the engineering equations presented in Chapter 5. The cost of diesel is assumed to $0.90 per gallon. For a diesel tractor with 140 horsepower (HP) the consumption of fuel per hour is given by

$$\begin{aligned} Diesel_{gph} &= (.06)\ (PTO_{\max})\ (.73) \\ &= (.06)\ (140)\ (0.73) \\ &= 6.132 \end{aligned}$$

where PTO_{max} is the maximum PTO horsepower per hour. Fuel cost is obtained by multiplying the hours of operation required for each operation by the cost of fuel per hour and fuel consumption per hour and then summing over the machine operations. For example, the cost of fuel per hour for the 140 HP tractor is $5.5188 [(0.9)(6.132)]. Lubrication is assumed to be 15% of fuel costs or $0.8278. Total fuel and lube cost is then $6.34662 per hour. As an example consider the fuel and lubrication costs of planting corn. The cost per hour for the tractor is divided by the field capacity of the planter to get a cost per acre. This gives a cost per acre of $\frac{6.34662}{8.6\bar{6}} = \$0.73225$. It is assumed in computing fuel and lubrication costs that the power unit operates 10% longer than the time required to complete the field operation. This cost per acre is thus multiplied by 1.1 to obtain a cost using January 1 prices of $0.8055 which is the cost reported for corn planting in Table 14A.4. This is then adjusted to the end of May using the inflation rate of 4%. Thus the cost per acre for planting corn of $0.8055 in January is adjusted to be $0.8188 [$(1.04)^{5/12}$ (0.8055)] as of the end of May. This is the fuel and lube cost reported in Table 14A.1. These nominal monthly costs for all operations are then summed to get the total in line 14 of $6.60. This total is also reported in Table 14A.1.

Interest is charged on each operating expense from the end of the month of occurrence to the end of the year. For planting fuel and lube it is charged from May 31 until the end of the year at a rate of 9.2%. This will give

$$\begin{aligned} ic &= (0.8188)(1.092)^{\frac{7}{12}} - 0.8188 \\ &= 0.043\,. \end{aligned}$$

Detailed information on the costs of all the machinery is contained in Table 14A.4.

TABLE 14.2 Detailed Notes (continued)

[m] Repair costs for each machine are estimated using the appropriate repair cost equations given in Chapter 5. Total repair costs are obtained by summing costs over the operations listed in Schedule 5a. Repair costs assume the power unit operates 10% longer than the time required to complete the operation just as with fuel and lubrication. For example consider the 140 HP tractor with a nominal purchase price at the beginning of 1992 of $53,610 and list price of $58,971. Total repairs over the 20-year lifetime of the tractor evaluated in end of 1992 dollars are given by

$$C_{rm}(140HP\,new\,tractor) = (.007)(58{,}971)(1.04)\left(\frac{6{,}000}{1{,}000}\right)^{2.0} = \$15{,}455.1197\,.$$

The list price is adjusted by the 4% inflation rate. The life of the tractor is 6,000 [(300 hours/year)(20 years)] hours. Dividing the total cost by 6,000 hours gives a per hour cost of $2.5758. Also consider the corn planter with a useful life of 15 years and annual use of 75 hours per year. The total repair cost is

$$C_{rm}(planter) = (.32)(18{,}095)(1.04)\left(\frac{1{,}125}{1{,}000}\right)^{2.1} = \$7{,}711.91$$

in end-of-year dollars. The cost per hour is $6.855 [(7,711.91)/(1,125)]. So the total cost per hour of machine time in planting corn is $9.4608 [(2.5758)+(6.8550)]. Since we assume that the tractor operates 10% more hours than the actual planting time, the cost per hour for the operation is $9.688 [(2.5758)(1.1)+(6.8550)]. The field capacity of the corn planter is 8 2/3 acres per hour. This gives a per acre cost of $1.1179. This is also reported in Table 14A.4. This is an end-of-year value. In Table 14A.1, this value is reported in the Plant Corn column in the Repair Cost per Acre (End-of-Year Prices) row. The convention we adopt for interest on repair expenses is to compute nominal interest on the year-end repair value rather than attempting to adjust repair cost to the month of operation. Thus the repair interest on planting corn is given by

$$\begin{aligned} ic &= (1.1179)(1.092)^{\frac{7}{12}} - 1.1179 \\ &= 0.05889\,. \end{aligned}$$

Also consider the repair costs for the row cultivation operation which uses the used 140 HP tractor. This tractor was purchased in 1987 for a nominal cost of $26,419. The tractor had 1,250 hours of use at the time of purchase. Ben Dairyman used the tractor 300 hours per year for the years 1987-91. The accumulated hours are 2,750 [1,250 + (300)(5)]. The tractor has total useful life of 20 years. Repair expenses are computed on the list price of a new tractor. Since this tractor is similar to the other 140 HP tractor, we can use the same list price to compute repair expenses. First we compute the cumulated expenses for the first 2,750 hours of use. This will give

TABLE 14.2 Detailed Notes (continued)

$$C_{rm}(140\,HP\ used\ tractor, 2{,}750\,hrs) = (.007)(58{,}971)(1.04)\left(\frac{2{,}750}{1{,}000}\right)^{2.0} = \$3{,}246.6484\,.$$

Then we compute the repair expenses for the total lifetime use of 5,750 hours [2,750 + (10)(300)]. This gives

$$C_{rm}(140\,HP\ used\ tractor, 5{,}750\,hrs) = (.007)(58{,}971)(1.04)\left(\frac{5{,}750}{1{,}000}\right)^{2.0} = \$14{,}194.0248\,.$$

The repair expenses that are included in the cost estimation are given by the difference or 14,194.0248 - 3,246.6484 = $10,947.3764. The cost per hour is then $3.649 [10,947.3764/3,000]. Notice that is quite a bit higher than the cost of the new 140 HP tractor ($2.58) since the used tractor is in the high repair cost range of its life. Now consider the repair costs for the row cultivator. This has a useful life of 15 years and annual use of 30 hours per year. The list price is $10,615. The total repair cost is

$$C_{rm}(row\,cultivator) = (.17)(10{,}615)(1.04)\left(\frac{450}{1{,}000}\right)^{2.2} = \$323.9429$$

in end-of-year dollars. The cost per hour is $0.7199 [(323.9429)/(450)]. So the total cost per hour of machine time in row cultivating is $4.73 [(3.649)(1.1)+(0.7199)]. The field capacity of the row cultivator is 17.45 acres per hour. This gives a per acre cost of $0.27. This is also reported in Table 14A.4. This is an end-of-year value. In Table 14A.1, this value is reported in the Row Cultivate column in the Repair Cost per Acre (End-of-Year Prices) row. Total repair costs are given by adding up the costs for each operation needed to grow corn. The total from Table 14A.1 is $5.39688. Interest on this expense is also given in Table 14A.1 and is $0.17.

[n] All input costs are assumed to occur on the last day of the month. Interest is compounded at a nominal monthly rate of 0.7361%. Real interest accrues at a monthly rate of 0.4074% while inflation occurs at a monthly rate of 0.32737%. An expense in January accrues interest for 11 months while an expense in May accrues interest for 7 months. The cost in this line is the sum of the implicit interest costs in the last column of the Table 14.2 for lines 5-13.

[o] Interest on fuel and lube comes from Table 14A.1. This comes from paying interest at a nominal rate for the appropriate number of months on the expense for each operation from the month of operation until December 31st. For row cultivating this gives an interest on fuel and lube expense of

$$\begin{aligned} ic &= (0.40789)(1.092)^{\frac{6}{12}} - 0.40789 \\ &= 0.01835\,. \end{aligned}$$

TABLE 14.2 Detailed Notes (continued)

Adding these interest expenses up over all the operations gives the total interest charges of $0.22235.

[p] Interest on repairs comes from Table 14A.1. This comes from paying interest at a nominal rate for the appropriate number of months on the expense for each operation from the month of operation until December 31st. For row cultivation this gives an interest on repair expense of

$$\begin{aligned} ic &= (0.27121)(1.092)^{\frac{6}{12}} - 0.27121 \\ &= 0.0122\,. \end{aligned}$$

Adding these interest expenses up over all the operations gives the total interest charges of $0.1706.

[q] Labor for corn production is based on the machine operations performed adjusted by a labor multiplier. We have data on the nominal (opportunity) cost for each type of labor for 1991. For the operator this is assumed to be $9.50 per hour. For the hired worker this is computed in Schedule 14.4. Total compensation for the first hired worker was $24,140. Dividing by the number of hours worked gives an average nominal wage of $9.466 [24,140/2,550]. This is adjusted to an average 1992 nominal wage of $9.845 [(9.466)(1.04)]. For the second hired worker compensation was equal to $4,885. This gives an implied nominal wage of $5.4277 [4,885/900]. The nominal value for 1992 is $5.645. This is a nominal average for the year. As in Chapter 13, we may want to create a nominal set of prices for each month that have this average. The easiest way to do this is using the procedure suggested in Chapter 2. What is wanted then is a real (and also nominal given the base period convention) price at the end of the year that when converted to monthly nominal prices has a simple average equal to the reported nominal average. Let $\bar{p}^n$ be the average nominal price for the year, p_j^n the nominal price in the j^{th} month and p_m the monthly rate of inflation. We can then find the real (nominal) price at the end of the year (p^r) as follows

TABLE 14.2 Detailed Notes (continued)

$$\bar{p}^{\,n} = \frac{\sum_{j=1}^{12} p_j^n}{12}$$

$$p_j^n = p^r (1+\pi_m)^{j-12}$$

$$\Rightarrow \bar{p}^{\,n} = \frac{\sum_{j=1}^{12} p^r (1+\pi_m)^{j-12}}{12}$$

$$\Rightarrow p^r = \frac{(12)(\bar{p}^{\,n})}{\sum_{j=1}^{12} (1+\pi_m)^{j-12}}$$

$$= \frac{(12)(\bar{p}^{\,n})}{(1+\pi_m) \sum_{j=1}^{12} (1+\pi_m)^{(j-12-1)}}$$

$$= \frac{(12)(\bar{p}^{\,n})}{(1+\pi_m) US_0(\pi_m, 12)}$$

$$= \frac{(12)(\bar{p}^{\,n})}{(1+\pi_m)\left(\frac{1-(1+\pi_m)^{-12}}{\pi_m}\right)}$$

where the last equalities comes from equations 2B.7 and 2B.8 in Appendix 2B where π replaces i in the summation. Writing the expression this way allows the use of canned annuity procedures for computing p^r. The nominal price for each month is then computed as

$$p_j^n = p^r (1+\pi_m)^{j-12}$$

where $p_{12}^n = p_r$. Consider, for example, the average nominal price for operator labor for 1992 of \$9.88. The real price of the year, which is also the nominal price for the end of December, is given by

TABLE 14.2 Detailed Notes (continued)

$$
\begin{aligned}
p^{r} &= \frac{(12)(\bar{p}^{\,n})}{(1+p_m)\left(\dfrac{1-(1+p_m)^{-12}}{p_m}\right)} \\
&= \frac{(12)(9.88)}{(1+0.003274)\left(\dfrac{1-(1+0.003274)^{-12}}{0.003274}\right)} \\
&= \frac{118.56}{(1.003274)\left(\dfrac{1-0.961535}{0.003274}\right)} \\
&= \frac{118.56}{(1.003274)(11.74848)} \\
&= 10.0586\,.
\end{aligned}
$$

The nominal price for a given month is given using the standard nominal adjustment. For example, the cost of operator labor at the end of July is given by

$$
\begin{aligned}
p_7^{n} &= 10.0586(1.003274)^{-5} \\
&= 10.0586(0.98379) \\
&= 9.8955\,.
\end{aligned}
$$

The real year-end values for the two hired workers and implicitly the operator's son are given in the last section of Table 14A.7. The real year-end wages are as follows:

Operator	\$10.05857
Hired Worker 1	\$10.02328
Hired Worker 2	\$ 5.74691

Table 14A.7 also reports a nominal wage for each month. The procedure used in estimating labor costs for corn production was to compute the total hours used by a given operation and then multiply it by the year-end real wage. This is then adjusted to a nominal labor cost for the month of interest. Consider the operation of row cultivation performed by the lower cost hired worker. The cost per acre is given by multiplying the cost per hour for the worker by the field multiplier (1.2 hours/acre) and then dividing by the field capacity of the row cultivator. This will give

$$
C_{labor}(row\,cultivator, real) = \left(\frac{(5.7469)(1.2)}{17.45}\right) = 0.395\,.
$$

TABLE 14.2 Detailed Notes (continued)

This can then be adjusted to the end of June using the monthly nominal inflation rate. This will give

$$\begin{aligned} C_{labor}(row\,cultivator, June\,cost) &= (0.3951)(1.003274)^{-6} \\ &= (0.395)(0.980579) \\ &= 0.3874\,. \end{aligned}$$

These costs are then added up across operations to get the total labor cost for each type of labor. The cost of hired labor of the first type is \$9.4145 while the cost of labor of the second type is \$0.448.

[r] The cost of operator labor is computed in a fashion similar to hired labor. The average nominal opportunity cost of the operator's labor in 1992 was projected to be \$9.88. The real year-end cost was projected to be \$10.05857. Consider the labor cost of planting corn. The field capacity of the planter is 8 2/3. This gives a real year-end cost per acre of

$$C_{labor}(corn\,planting, real) = \left(\frac{(10.05857)(1.2)}{8.6\overline{6}}\right) = 1.3927\,.$$

The cost in May is given by

$$\begin{aligned} C_{labor}(corn\,planting, May\,cost) &= (1.3927)(1.003274)^{-7} \\ &= (1.3927)(0.97738) \\ &= 1.3612\,. \end{aligned}$$

Total operator labor costs are \$1.71.

[s] Interest is charged on each labor expense at a monthly nominal rate from the month of the expense to December 31st. Consider the interest charge on the labor for planting corn. This expense will accrue interest for 7 months. The expense is given by

$$\begin{aligned} ic &= (1.3612)(1.092)^{\frac{7}{12}} - 1.3612 \\ &= 0.0717\,. \end{aligned}$$

Total interest expenses for labor are obtained by aggregating the expenses over operations and labor types. The total is \$0.3774.

TABLE 14.2 Detailed Notes (continued)

[t] Capital recovery is based on the difference between the beginning value (list price) of the various pieces of equipment and their real salvage value at the end of their useful life. This salvage value is discounted back to the present at a real interest rate of 5% and then subtracted from the initial value to obtain a net present cost of the equipment. This is then converted to a real annual annuity following the procedures outlined in Chapter 2 and equation 6.7.

Salvage values for each machine are computed using the formulas from Chapter 6. Where there is a clear match between the particular machine and the categories of Cross and Perry (1995, 96), their remaining value equations are used. When there is not a close match, the older ASAE remaining value equations are used. Such mixing of estimates is probably not a good idea, but is used here to illustrate a method that can be used when better estimates of remaining value are not available. Consider the computation of the remaining value for the 140 HP tractor used by Ben and Bev. The nominal list price at the beginning of 1992 is \$58,971 (Schedule 14.7). The projected useful life is 20 years with annual use of 300 hours per year. We compute the salvage value in the same dollars as the initial list price. We then adjust for inflation after computing the capital recovery cost. Using the equation from Table 6.3 we get an estimated remaining value of

$$\begin{aligned} rv(140\,HP\ tractor, real)_{C\&P} &= (58{,}971)(0.97690 - (0.02301)(20)^{0.76} - (0.0012)(300)^{0.6})^{3.85} \\ &= 16{,}286.248\,. \end{aligned}$$

Notice that the salvage value of the used 140 HP tractor is slightly higher at \$16,368 because it is used less hours over its lifetime given annual use of only 250 hours per year by the previous owner.

The capital service cost of the tractor is computed using equation 6.7. The purchase price, not the list price, is used in the calculation.

$$\begin{aligned} CSC_{140\ HP\ tractor} &= \frac{\left(PP - \dfrac{SV}{(1+r)^{n}}\right)}{\left(\dfrac{1 - (1+r)^{-n}}{r}\right)} = \frac{\left(53{,}610 - \dfrac{16{,}286.25}{(1.05)^{20}}\right)}{\left(\dfrac{1 - (1.05)^{-20}}{.05}\right)} \\ &= \frac{47{,}471.8836}{12.46221} = 3{,}809.266\,. \end{aligned}$$

Because this is beginning-of-year value it is multiplied by (1.04) to obtain a year-end value of \$3,961.6364. This is the value reported in Table 14A.2 in the Perry-Cross (P-C) capital recovery column. Taxes, insurance, and shelter (TIS) are charged at 2% of the average of purchase price and salvage value. This gives

TABLE 14.2 Detailed Notes (continued)

$$
\begin{aligned}
TIS_{140\ HP\ tractor} &= \left(\frac{PP + SV}{2}\right)(0.02) = \frac{53{,}610 + 16{,}286.25}{2}(0.02) \\
&= (34{,}948.125)(0.02) = 698.9625\,.
\end{aligned}
$$

Multiplying by 1.04 will give (698.9625)(1.04) = $726.92. The sum of this and the capital recovery will give the total overhead cost for the tractor. This yields 726.92 + 3,961.636 = $4,688.56. Dividing this by 300 hours of annual use will give $15.63 per hour for overhead. This is the figure reported in Table 14A.3.

We can perform a similar operation for the row cultivator. The nominal list price of a new like cultivator at the beginning of 1992 from Table 14A.2 is $10,615. The projected useful life is 15 years with annual use of 30 hours per year. We compute the salvage value in the same dollars as the initial list price. We then adjust for inflation after computing the capital recovery cost. Using the equation from Table 6.2 we get an estimated remaining value of

$$
\begin{aligned}
rv(140\ HP\ tractor, real)_{ASAE} &= (10{,}615)(0.60)(0.885)^{15} \\
&= 1{,}019.11\,.
\end{aligned}
$$

The capital service cost of the cultivator is given by

$$
\begin{aligned}
CSC_{row\ cultivator} &= \frac{\left(PP - \dfrac{SV}{(1+r)^n}\right)}{\left(\dfrac{1 - (1+r)^{-n}}{r}\right)} = \frac{\left(9{,}650 - \dfrac{1{,}019.11}{(1.05)^{15}}\right)}{\left(\dfrac{1 - (1.05)^{-15}}{.05}\right)} \\
&= \frac{9{,}159.7907}{10.3796} = 882.48\,.
\end{aligned}
$$

Because this is beginning-of-year value it is multiplied by (1.04) to obtain a year-end value of $917.78. This is the value reported in Table 14A.2 in the Cross-Perry (C-P) capital recovery column. Taxes, insurance, and shelter (TIS) are charged at 2% of the average of purchase price and salvage value. This gives

$$TIS_{140\ HP\ tractor} = \left(\frac{PP + SV}{2}\right)(0.02) = \frac{9{,}650 + 1{,}019.1}{2}(0.02)$$
$$= (5{,}334.55)(0.02) = 106.69\,.$$

TABLE 14.2 Detailed Notes (continued)

Multiplying by 1.04 will give (106.69)(1.04) = $110.96. The sum of this and the capital recovery will give the total overhead cost for the cultivator. This yields $1,028.74. Dividing this by 30 hours of annual use will give $34.29 per hour for overhead. This is the figure reported in Table 14A.3. Detailed calculations for both 140 HP tractors and the row cultivator are contained in Table 14A.6.

Table 14A.3 gives overhead costs per year and per hour for all the machines owned and used by Ben and Bev. Ben planned to sell the first 90 HP tractor early in 1992 and use the newer 90 HP tractor as a replacement. Therefore, the second 90 HP tractor was used on computing all costs of production.

Per acre overhead costs are computed in a manner similar to repair costs. Consider the activity of row cultivation using the row cultivator and the used 140 HP tractor. The overhead cost per hour of the tractor is $12.40 while that of the cultivator is $34.49. Since we assume that the tractor operates 10% more hours than the actual planting time, the cost per hour for the operation is $47.93 [(12.40)(1.1)+(34.29)]. The field capacity of the cultivator is 17.45 acres per hour. This gives a per acre cost of $2.74. This is also reported in Table 14A.4. This is an end-of-year value. In Table 14A.1, this value is reported in the Row Cultivate column in the Overhead Costs per Acre (End of Year) row. The sum of these expenses for all operations is in the last column of Table 14A.1 and is the Capital Recovery of Machinery & Equipment Inventory cost reported in Table 14.2. The total is $42.1516.

[u] The cash rental rate for the quality of land is $85 per acre. Each acre of corn requires 1 acre for corn plus .0625 acre for the ARP. This gives a total cost of $90.3125 [(1.0625)(85)]. It is assumed that this is all paid at the end of the year or alternatively that the $85 per acre cash rent is in year-end dollars.

[v] Insurance on machinery and equipment for 1991 is included in Table 14A.8. This could be allocated for 1992 using the 1991 data and a 4% inflation rate. For corn for grain this would give an allocation of $0.6537 [(880)(1.04)(0.11) ÷ 154]. But because insurance was already calculated in footnote [t], no entry is made in line 28 of the estimate.

[w] General farm overhead includes the corn enterprise's share of office expense, the farm overhead portion of fuel, lube, and utilities and the farm overhead portion of maintenance and repairs. Using the data in Schedule 14.8 these costs total ($1,194 + 3,500 + 7,165 + 1,235) $13,094. The enterprise share for corn is $1,440.34 or $9.3528 per acre. Adjusting for 4% inflation gives $9.73. Complete data is in Table 14A.8.

Table 14.3 A Sample Detailed CAR Summary for a Soybean Budget
1992 Projected Costs and Returns for Soybean Per Planted Acre on Owned Land, Detailed
Ben & Bev Dairyman Farm, Upper Midwest, USA (See Chapter 14 for a complete description of the farm)
Prepared by John Q. Taskforce, Department of Agricultural Economics, Anonymous State University, March 1992

	Item	Units	Quantity	Price	Month of Revenue/Expense	Value	Implicit interest
	Gross Value Of Production:						
1	Soybean (a)	Bu	40.00	5.500	12	220.00	0.000
2	Interest on Receipts to December (b)			0.092		0.00	
3	Total Revenue (c)					220.00	
	Operating Costs						
4	Seed (d)	lb	70.00	0.142	2	9.94	0.756
5	Pursuit (e)	Ac	1.00	13.2	6	13.20	0.594
6	Crop Insurance (f)	Ac	1.00	3.94	6	3.94	0.177
7	Labor to walk crop (g)	HR	0.40	6	7	2.40	0.090
8	Fuel & Lube (h)					4.41	0.129
9	Repairs (i)					3.89	
10	Interest on Oper. Inputs to Dec (j)					1.62	
11	Interest on Fuel & Lube to Dec (k)					0.13	
12	Interest on Repairs to Dec (l)					0.12	
13	Total Operating Costs (c)					39.64	
	Allocated Overhead						
14	Hired Labor 1(m)	HR	0.5121			5.09	
15	Hired Labor 2(m)	HR	0.0688			0.39	
16	Opportunity Cost of Operator Labor (n)	HR	0.1740			1.71	
17	Opportunity Cost of Son's Labor (n)	HR	0.0000				
18	Total Implicit Interest on Labor (o)					0.21	
19	Total Labor cost (p)					7.39	
20	Capital Recovery of Mach & Eq Inv(q)					49.28	
21	Opportunity Cost of Land (r)	Ac	1.0000	85.000		85.00	
22	Insurance (s)					0.00	
23	General Farm Overhead (t)					10.68	
24	Total Allocated Overhead (c)					159.75	
25	Total Costs Listed (c)					199.39	
26	Value Of Prod. Less Total Oper. Costs (c)					180.36	
27	Value Of Prod. Less Total Costs Listed (c)					20.61	

TABLE 14.3 1992 Projected Costs and Returns for Soybeans Per Planted Acre on Owned Land, Detailed Notes

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[a] Ben's best estimate of the soybean price in December is $5.50 per bushel. The expected yield is 40 bushels per acre. This gives revenue of $220.00 [(5.50)(40)]. Because the revenue occurs at the end of the year, no interest accrues on receipts.

[b] Because all revenue payments were assumed to be received on December 31, 1992, there is no implicit interest on revenue. This line is the total of the implicit interest column in row 1 of the table.

[c] Totals may not add due to rounding.

[d] Seed was planted at a rate of 70 lbs per acre. The price per lbs was projected to be $0.142 for a total cost per acre of $9.94. Seed was purchased in February though it was not planted until May. The implicit interest was computed from February 28 until the end of the year.

[e] A herbicide (Pursuit) was applied in June. The cost of the herbicide is $13.20 per acre. The operator uses his own tractor and sprayer to apply the herbicide. The cost of the use of the tractor and sprayer is included in the lines on repair and capital recovery.

[f] Crop insurance was $3.94 per acre. It assumed that the premiums are due in June.

[g] The operator hired additional labor to walk the soybean crop in July. He paid $6.00 per hour for the labor. An acre took 0.4 hours of labor for a cost per acre of $2.40.

[h] Fuel and lubrication was computed using the engineering equations presented in Chapter 5. For a more complete discussion see note [l] to Table 14.2. The fuel and lube cost is $4.41 and is reported in Table 14A.9 in the row labeled Fuel and Lube Cost per Acre (Current Month Prices) and the total column.

[i] Repair costs for each machine are estimated using the appropriate repair cost equations given in Chapter 5. Total repair costs are obtained by summing costs over the operations listed in Schedule 5b. Repair costs assume the power unit operates 10% longer than the time required to complete the operation just as with fuel and lubrication. More detail is contained in note [m] in Table 14.2. Total repair costs are given by adding up the costs for each operation needed to grow soybeans. The total from the row labeled Repair Cost per Acre (End-of-Year Prices) in Table 14A.9 is $3.89.

[j] All input costs are assumed to occur on the last day of the month. Interest is compounded at a nominal monthly rate of 0.7361%. Real interest accrues at a monthly rate of 0.4074% while inflation occurs at a monthly rate of 0.32737%. An expense in January accrues interest for 11 months while an expense in May accrues interest for 7 months. The cost in this line is the sum of the implicit interest costs in the last column of the Table 14.3 for lines 4-7.

TABLE 14.3 Detailed Notes (continued)

[k] Interest on fuel and lube comes from Table 14A.9. This comes from paying interest at a nominal rate for the appropriate number of months on the expense for each operation from the month of operation until December 31st. Adding these interest expenses up over all the operations gives the total interest charges of $0.13.

[l] Interest on repairs comes from Table 14A.9. This comes from paying interest at a nominal rate for the appropriate number of months on the expense for each operation from the month of operation until December 31st and is $0.12265.

[m] Labor for soybean production is based on the machine operations performed adjusted by a labor multiplier. A description of how the cost of this labor was computed is contained in note [q] for Table 14.2. The hired labor costs are added up across operations to get the total labor cost for each type of labor. The cost of hired labor of the first type is $5.09 while the cost of labor of the second type is $0.39.

[n] The cost of operator labor is computed in a fashion similar to hired labor. The average nominal opportunity cost of the operator's labor in 1992 was projected to be $9.88. The real year-end cost was projected to be $10.05857. Total operator labor costs are $1.71, the same as with corn production, because the operator performs the same tasks for both crops.

[o] Interest is charged on each labor expense at a monthly nominal rate from the month of the expense to December 31st. Total interest expenses for labor are obtained by aggregating the expenses over operations and labor types. The total is $0.2084 ≈ 0.21.

[p] Total labor cost is found by adding up the various types of labor expense and gives $7.39.

[q] Capital recovery is based on the difference between the beginning value (list price) of the various pieces of equipment and their real salvage value at the end of their useful life. This salvage value is discounted back to the present at a real interest rate of 5% and then subtracted from the initial value to obtain a net present cost of the equipment. This is then converted to a real annual annuity following the procedures outlined in Chapter 2 and equation 6.7. Consider the computation of the remaining value for the 140 HP used tractor owned by Ben and Bev. The nominal list price at the beginning of 1992 is $58,971 (Schedule 14.7). The projected useful life is 20 years with annual use of 250 hours of use for the first 5 years of life and 300 hours of use for the remaining 15 years of life. This gives total lifetime use of 5,750 hours. Average use per year is 287.5 hours. We compute the salvage value in the same dollars as the initial list price. We then adjust for inflation after computing the capital recovery cost. Using the equation from Table 6.3 we get an estimated remaining value at the end of 20 years of

$$rv(140\ HP\ used\ tractor, real)_{C\&P} = (58{,}971)(0.97690 - (0.02301)(20)^{0.76} - (0.0012)(287.5)^{0.6})^{3.85}$$
$$= 16{,}367.5876\ .$$

TABLE 14.3 Detailed Notes (continued)

Notice that the salvage value of the this used 140 HP tractor is slightly higher than the new 140 HP tractor because it is used less hours over its lifetime given annual use of only 250 hours per year by the previous owner.

The capital service cost of the tractor is computed using equation 6.7. The used purchase price, not the list price, is used in the calculation.

$$CSC_{140\ HP\ used\ tractor} = \frac{\left(PP - \dfrac{SV}{(1+r)^n}\right)}{\left(\dfrac{1 - (1+r)^{-n}}{r}\right)} = \frac{\left(33{,}745.8588 - \dfrac{16{,}367.5876}{(1.05)^{10}}\right)}{\left(\dfrac{1 - (1.05)^{-10}}{.05}\right)}$$

$$= \frac{23{,}697.5798}{7.7217349} = 3{,}068.945\ .$$

Because this is beginning-of-year value it is multiplied by (1.04) to obtain a year-end value of \$3,191.7028. This is the value reported in Table 14A.2 in the Perry-Cross (P-C) capital recovery column. Taxes, insurance, and shelter (TIS) are charged at 2% of the average of purchase price and salvage value. This gives

TABLE 14.3 Detailed Notes (continued)

$$TIS_{140\ HP\ tractor} = \left(\frac{PP + SV}{2}\right)(0.02) = \frac{33{,}745.8588 + 16{,}367.5876}{2}(0.02)$$
$$= (25{,}056.7232)(0.02) = 501.134\,.$$

Multiplying by 1.04 will give (501.134)(1.04) = $521.18. The sum of this and the capital recovery will give the total overhead cost for the tractor. This yields 521.18 + 3,191.70 = $3,712.88. Dividing this by 300 hours of annual use will give $12.38 per hour for overhead. This is the figure reported in Table 14A.3. Total capital recovery cost for all machines is $49.28. Detailed machinery computations are contained in Table 14A.9.

[r] The cash rental rate for the quality of land is $85 per acre. Each acre of soybean requires 1 acre of land for a total cost of $85.00. It is assumed that this is all paid at the end of the year, or alternatively, that the $85 per acre cash rent is in year-end dollars.

[s] Because insurance is included in footnote [q], no entry is made here. See footnote [v] of Table 14.2.

[t] General farm overhead includes the soybean enterprise's share of office expense, the farm overhead portion of fuel, lube, and utilities and the farm overhead portion of maintenance and repairs. Using the data in Table 14A.8, these costs total $13,617.76 for 1992. The enterprise share for soybeans is $1,089.42 or $10.68 per acre.

Table 14.4 A Sample Detailed CAR Summary for an Alfalfa Establishment Budget
1992 Projected Costs and Returns for Alfalfa Establishment Per Planted Acre on Owned Land, Detailed

Ben & Bev Dairyman Farm, Upper Midwest, USA (See Chapter 14 for a complete description of the farm)

Prepared by John Q. Taskforce, Department of Agricultural Economics, Anonymous State University, March 1992

	Item	Units	Quantity	Price	Month of Revenue/Expense	Value	Implicit interest
	Gross Value Of Production:						
1	Oatlage (a)	ton	2.50	15.000	5	37.50	1.976
2	Alfalfa Hay (b)	ton	1.50	50.000	8	75.00	2.233
3	Interest on Receipts to December (c)			0.092		4.21	
4	Total Revenue (d)					116.71	
	Operating Costs						
5	Oat Seed (e)	Bu	3.50	7	4	24.50	1.481
6	Alfalfa Seed (f)	lb	15.00	3.73	4	55.95	3.381
7	Dry Fertilizer (3-8-0) (g)	cwt	3.00	3.33	4	9.99	0.604
8	Potash (0-0-60) (g)	cwt	2.00	7.35	4	14.70	0.888
9	Custom Fert. Appl. (g)	Ac	1.00	3	4	3.00	0.181
10	Fuel & Lube (h)					11.67	0.554
11	Repairs (i)					9.20	
12	Interest on Oper. Inputs to Dec (j)					6.53	
13	Interest on Fuel & Lube to Dec (k)					0.55	
14	Interest on Repairs to Dec (l)					0.44	
15	Total Operating Costs (d)					136.53	
	Allocated Overhead						
16	Hired Labor 1(m)	HR	1.6132			15.82	
17	Hired Labor 2(m)	HR	0.4768			2.70	
18	Opportunity Cost of Operator Labor (n)	HR	0.4714			4.62	
19	Opportunity Cost of Son's Labor (n)	HR	0.0000				
20	Total Implicit Interest on Labor (o)					1.14	
21	Total Labor cost (p)					24.29	
22	Capital Recovery of Mach & Eq Inv(q)					87.81	
23	Opportunity Cost of Land (r)	Ac	1.0000	85.000		85.00	
24	Insurance (s)					0.00	
25	General Farm Overhead (t)					4.54	
26	Total Allocated Overhead (d)					225.93	
27	Total Costs Listed (d)					362.46	
28	Value Of Prod. Less Total Oper. Costs (d)					-19.82	
29	Value Of Prod. Less Total Costs Listed (d)					-245.75	

TABLE 14.4 1992 Projected Costs and Returns for Alfalfa Establishment Per Planted Acre on Owned Land, Detailed Notes

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[a] Ben's best estimate of the price of oatlage (chopped green oats) at the end of May is $15.00 per ton. He expects to harvest 2.5 tons. This gives revenue of $37.50 [(2.5)(15)].

[b] Ben figures to get one cutting of alfalfa for the year in August. He projects the yield to be 1.5 tons. The projected alfalfa hay price in August is $50.00 per ton for revenue of $75.00.

[c] Interest on both revenue items are calculated from the time of occurrence until the end of December. For example, the implicit interest on alfalfa hay is given by

$$\begin{aligned} ic &= R(1+i)^{\frac{n}{12}} - R \\ &= (75)(1.092)^{\frac{4}{12}} - 75 \\ &= 2.233286 \approx 2.23 . \end{aligned}$$

Line 3 is the total of the implicit interest columns in rows 1 and 2 of the table.

[d] Totals may not add due to rounding.

[e] Oat seed was planted at a rate of 3.5 bushels per acre. The price per lbs was projected to be $7.00 for a total cost per acre of $24.50. Seed was purchased in and planted in April. The implicit interest is computed from April 30th until the end of the year.

[f] Alfalfa seed was planted at a rate of 15 pounds per acre. The price per pound in April was projected to be $3.73 for a total cost per acre of $55.95. Seed was purchased in and planted in April. The implicit interest was computed from April 30th and is

$$\begin{aligned} ic &= (55.95)(1.092)^{\frac{8}{12}} - 55.95 \\ &= 3.381 . \end{aligned}$$

[g] Three hundred pounds of dry fertilizer (3-8-0) and 200 pounds of potash (0-0-60) are applied in April by a custom applicator. The cost of application is $3.00 per acre.

[h] Fuel and lubrication was computed using the engineering equations presented in Chapter 5. For a more complete discussion see note [l] to Table 14.2. The fuel and lube cost is $11.67 and is reported in Table 14A.10 in the row labeled Fuel and Lube Cost per Acre (Current Month Prices) and the total column.

TABLE 14.4 Detailed Notes (continued)

[i] Repair costs for each machine are estimated using the appropriate repair cost equations given in Chapter 5. Total repair costs are obtained by summing costs over the operations listed in Schedule 5c. Repair costs assume the power unit operates 10% longer than the time required to complete the operation just as with fuel and lubrication. More detail is contained in note [m] in Table 14.2. Total repair costs are given by adding up the costs for each operation needed to grow soybeans. The total from the row labeled Repair Cost per Acre (End-of-Year Prices) in Table 14A.10 is $9.198.

[j] All input costs are assumed to occur on the last day of the month. Interest is compounded at a nominal monthly rate of 0.7361%. Real interest accrues at a monthly rate of 0.4074% while inflation occurs at a monthly rate of 0.32737%. An expense in January accrues interest for 11 months while an expense in May accrues interest for 7 months. The cost in this line is the sum of the implicit interest costs in the last column of Table 14.3 for lines 5-9.

[k] Interest on fuel and lube comes from Table 14A.10. This comes from paying interest at a nominal rate for the appropriate number of months on the expense for each operation from the month of operation until December 31st. This is reported in Table 14A.10 in the line labeled Operating Interest on Fuel and Lube (Current Month Prices). Adding these interest expenses up over all the operations gives the total interest charges of $0.554.

[l] Interest on repairs comes from Table 14A.10. This comes from paying interest at a nominal rate for the appropriate number of months on the expense for each operation from the month of operation until December 31st and is $0.43767.

[m] Labor for alfalfa establishment is based on the machine operations performed adjusted by a labor multiplier. A description of how the cost of this labor was computed is contained in note [q] for Table 14.2. The hired labor costs are added up across operations to get the total labor cost for each type of labor. The total cost per acre for hired labor of the first type is $15.82 while the cost of labor of the second type is $2.70.

[n] The cost of operator labor is computed in a fashion similar to hired labor. The average nominal opportunity cost of the operator's labor in 1992 was projected to be $9.88. The real year-end cost was projected to be $10.05857. Total operator labor costs are $4.62. This is quite a bit higher than for the corn or soybeans because the operator plants both oats and alfalfa.

[o] Interest is charged on each labor expense at a monthly nominal rate from the month of the expense to December 31st. Total interest expenses for labor are obtained by aggregating the expenses over operations and labor types. The total is $1.14475.

[p] Total labor cost is found by adding up the various types of labor expense and gives $24.29.

TABLE 14.4 Detailed Notes (continued)

[q] Capital recovery is based on the difference between the beginning value (list price) of the various pieces of equipment and their real salvage value at the end of their useful life. This salvage value is discounted back to the present at a real interest rate of 5% and then subtracted from the initial value to obtain a net present cost of the equipment. This is then converted to a real annual annuity following the procedures outlined in Chapter 2 and equation 6.7. More detail is contained in note [t] of Table 14.2. Total capital recovery cost is $87.8065. Detailed machinery computations are contained in Table 14A.10.

[r] The cash rental rate for the quality of land is $85 per acre. Each acre of alfalfa requires 1 acre of land for a total cost of $85.00. It is assumed that this is all paid at the end of the year, or alternatively, that the $85 per acre cash rent is in year-end dollars.

[s] Because insurance is included in footnote [q], no entry is made here. See footnote [v] of Table 14.2.

[t] General farm overhead includes the alfalfa establishment's share of office expense, the farm overhead portion of fuel, lube, and utilities and the farm overhead portion of maintenance and repairs. Using the data in Table 14A.8, these costs total $13,617.76 for 1992. The enterprise share for alfalfa establishment is $136.17 or $4.54 per acre.

Schedule 14.1: 1991 Crop Acreage and Production - Ben & Bev Dairyman, Upper Midwest, U. S. A.

Crop	Planted Acres	Harvested Acres	ASCS Base	Payment Acres	Flex Acres	ARP Acres	Production	ASCS Yield	Units	Landlord's Share
OWNED LAND										
Corn	93	93	151	120	19.7	11.3	11,904	108	bu	0
Corn Silage	27	27					270		ton	0
Oats Silage	15	15					40		ton	0
Alfalfa - Haylage[a]	62	62					264		ton	0
Hay							146		ton	0
Soybean	95	95					4,294		bu	0
ARP	11.3	-					-			0
Total Owned Cropland	303.3	292					XX			XX
CASH RENTAL LAND										
Corn	21	21					1,690		bu	0
Oats Silage	15	15					30		ton	0
Alfalfa - Haylage[a]	21	21					81		ton	0
Hay							45		ton	0
Total Cash Rental Cropland	57	57					XX			XX
SHARE RENTAL LAND										
Corn	40	40					4,776		bu	1,592
Soybeans	7	7					285		bu	95
Total Share Rental Cropland	47	47					XX			XX
TOTAL CROP LAND	407	396					XX			XX

[a] Multiply by .4 to obtain equivalent tons of hay.

Schedule 14.2: Livestock Production During 1991 - Ben & Bev Dairyman, Upper Midwest, U. S. A.

	Milking Herd
Ave. No. Cows	89
Milk Sales Per Cow (lbs)	21,019
Cull Sales (Hd)	32
Bull Calves Trans. to Hired Worker 1 (Hd)	41
	Rearing Young Stock
Bulls (Hd)	5
Heifers Trans. to Herd (Hd)	37

Schedule 14.3: 1991 Inventory, Use and Sales of Feed and Grain - Ben & Bev Dairyman, Upper Midwest, U. S. A.

Crop	Beginning Inventory	Production	Use for Feed & Seed	Sales	Ending Inventory
Corn	22,145	16,778	15,646	5,777	17,500
Corn Silage	225	270	270	0	225
Oatlage	46	70	70	0	46
Alfalfa Haylage	225	250	252	0	223
Alfalfa Hay	119	152	149	0	122
Soybeans	462	4,484	-	2,698	2,248

Schedule 14.4: 1991 Labor Hours and Cash Wages - Ben & Bev Dairyman, Upper Midwest, U. S. A.

	Compensation			Annual Hours of Work								
Individual	Cash	In Kind	Total	Dairy	Corn	Corn Silage	Oats-Alf. Estab.	Alfalfa	Soybeans	ARP Acres	Over-head	Total
Farm Operator				2,437	154	27	30	80	102	-	720	3,550
Spouse											30	30
Son (age 12)				330			30	100				460
Hired Worker 1	17,990	6,150[a]	24,140	2,173	191	54	30	45	52	5		2,550
Hired Worker 2	4,885		4,885	734	40	14	15	45	41	11		900
Hours Per Cow/Acre				63.8	2.5	3.5	3.5	3.25	1.9	1.45		

[a] The operator gives hired worker 1 the bull calves as part of his compensation. During 1991 worker 1 received 41 bull calves valued at $150 each.

Schedule 14.5A: Projected 1992 Operating Inputs and Machinery Operations For Corn After Soybean - Ben & Bev Dairyman, Upper Midwest, U.S.A.

	Machinery Operations				Operating Input			
MONTH	Operation	Hrs/Ac[a]	Machine 1	Machine 2	Item	Quantity/Acre	Units	Price/Unit
Nov	Apply Anhydrous	.124	Tractor 140 HP	Rented Applicator	Applicator Rental	1	ac	$0.50
					Anhydrous Ammonia	120	lb	0.094
Apr-May	Field Cultivate	.064	Tractor 140 HP	26' Field Cultivator				
	Plant	.138	Tractor 140 HP	8-36" Planter	Seed	28	1000	0.882
					Fertilizer 8-32-16	1	ac	8.95
					Zinc	1	lb	0.32
May	Rotary Hoe (30%)	.012	Tractor 90 HP	25' Rotary Hoe				
	Apply Herbicide	.036	Tractor 90 HP	66' Sprayer	Extrazine	2.2	lb	3.79
Jun	Cultivate	.069	Tractor 140 HP	8-36" Cultivator				
					Insurance	1	ac	4.45
Aug	Aerial Application of Herbicide				2-4-D and Custom Application	1	ac	7.25
Oct	Harvest	.131	Combine	4-36" Header				
	Haul Corn	.200	Tractor 140 HP	Four 300 Bu Grav. Wag.				
	Put Corn in Oxygen Limiting Silos	.200	Tractor 90 HP	Blower				
Nov	Chisel	.206	Tractor 140 HP	12' Chisel				
May	Plant Set Aside	.014	Tractor 90 HP	12' Drill	Seed	0.1	Bu	3.00
Aug	Mow Set Aside	.011	Tractor 90 HP	14' Mower				

[a] Hours per acre are the hours per acre for the implement multiplied by 1.2 and then adjusted for times over the acre.

Schedule 14.5B: Projected 1992 Operating Inputs and Machinery Operations For Soybean After Corn - Ben & Bev Dairyman, Upper Midwest, U. S. A.

MONTH	Machinery Operations				Operating Input			
	Operation	Hr/Ac[a]	Machine 1	Machine 2	Item	Quantity/Acre	Units	Price/Unit
May	Field Cultivate	.064	Tractor 140 HP	26' Field Cultivator				
	Plant	.138	Tractor 140 HP	13 Row Skip Planter(22.5' Wide)	Seed	70	lb	$0.142
	Rotary Hoe (30%)	.012	Tractor 90 HP	25' Rotary Hoe				
Jun	Apply Herbicide	.036	Tractor 90 HP	66' Sprayer	Pursuit	1	ac	13.20
	Cultivate	.069	Tractor 140 HP	13 Row Soybean Cultivator				
					Insurance	1	ac	3.94
Jul	Spot Walking				Hired Labor	0.4	hr	6.00
Oct	Harvest	.236	Combine	20' Header				
	Haul Grain	.200	Tractor 140 HP	Four 300 Bu Gravity Wagons				

[a] Hours per acre are the hours per acre for the implement multiplied by 1.2 and then adjusted for times over the acre.
[b]One-half are stored in a bin on the farm (average distance is 2 miles round trip) and the remaining one-half are hauled to the elevator (12 miles round trip).

Schedule 14.5C: Projected 1992 Operating Inputs and Machinery Operations For Alfalfa Establishment After Corn - Ben & Bev Dairyman, Upper Midwest, U. S. A.

	Machinery Operations				Operating Input			
MONTH	Operation	Hr/Ac[a]	Machine 1	Machine 2	Item	Quantity/Acre	Units	Price/Unit
Apr	Apply Fertilizer				3-8-0	3	cwt	$ 3.33
					0-0-60	2	cwt	7.35
					Custom Application	1	ac	3.00
	Field Cultivate	.064	Tractor 140 HP	26' Field Cultivator				
	Plant Oats	.236	Tractor 90 HP	12' Drill	Oats Seed	3.5	bu	7.00
	Plant Alfalfa	.236	Tractor 90 HP	12' Alfalfa Seeder	Alfalfa Seed	15	lb	3.73
Jun	Swath Oats	.177	Tractor 90 HP	14' Swather				
	Chop Oatlage	.337	Tractor 140 HP	Forage Harvester				
	Haul Oatlage	.600	Tractor 90 HP	Three Forage Wagons				
	Blow Oatlage	.200	Tractor 140 HP	Blower				
Aug	Swath Alfalfa	.177	Tractor 90 HP	14' Swather				
	Bale Hay	.236	Tractor 90 HP	Baler, Sq Bale				
	Haul Bales	.300	Tractor 140 HP	Three Hay Racks				

[a]Hours per acre are the hours per acre for the implement multiplied by 1.2 and then adjusted for times over the acre.

Schedule 14.6: Buildings and Improvements 12/31/91 - Ben & Bev Dairyman, Upper Midwest, U. S. A.

Item	Useful Life Remaining	Year of Purchase	Purchase Price	Book Value	Market Value[c]	Salvage Value	Annual Repairs	Percent Allocation Dairy	Overhead
Manure Pit[a]	10 Years	77	$ 5,342	$ 0	$ 2,000	0	[d]	100	
Harvestor[a]	20	77	18,000	4,900	8,000	0	[d]	100	
Heifer Barn[a]	20	78	12,320	3,770	5,000	0	[d]	100	
Harvestor[a]	20	80	49,890	26,000	20,000	0	[d]	100	
Dairy Barn[b]	15	80	40,000	16,500	40,000	0	[d]	100	
Stave Silo[b]	20	80	12,000	5,000	5,000	0	[d]	100	
Stave Silo[b]	10	80	2,000	0	1,000	0	[d]	100	
Old Barn[b]	10	80	4,000	0	3,000	0	[d]	100	
Hay Shed[b]	20	80	4,000	1,650	3,000	0	[d]	100	
Fences[b]	3	80	3,000	0	0	0	[d]	100	
Drain Tile[b]	20	80	32,946	9,300	30,000	0	[d]		100
Drying Bin[b]	10	80	2,500	150	1,500	0	[d]		100
Well & Water Sy[b]	10	80	10,000	4,200	5,000	0	[d]		100
Machine Shed[a]	30	87	22,923	18,797	20,000	0	[d]		100

SCHEDULE 14.6 (continued)

Item	Useful Life Remaining	Year of Purchase	Purchase Price	Book Value	Market Value[c]	Salvage Value	Annual Repairs	Percent Allocation Dairy	Overhead
Drain Tile[a]	30	91	2,370	2,370	2,000	0	[d]		100
Total Bldg & Imp		XX	XX	92,637	145,500	XX			
Land[a]		80	219,987	219,987	319,688	XX			
Total				312,624	465,188	XX			

[a] Purchased by Ben Dairyman in the year indicated.

[b] Purchased as part of the farm April 1 1980. The "purchase price" is the value established by the accountant in setting up the depreciation schedule in April 1980.

[c] Ben Dairyman's estimate of the amount the facility would add to the sale value of the farm if the farm were to be sold during 1992.

[d] Repairs and maintenance totaled $17,689 in 1991, which is approximately the average over the past 5 years. Of the total, $10,524 was for buildings and improvements allocated to the dairy enterprise, and $7,165 was spent to maintain buildings, improvements, driveways, etc. allocated to overhead.

Schedule 14.7: Machinery and Equipment Inventory 12/31/91 and Average Annual Use

Ben & Bev Dairyman, Upper Midwest, U. S. A.

Description	Size	Year of Purchase	Purchase Price	1991 Book Value	1992 Replacement Purchase Cost	List Price	Useful Life	Ann Use	Salv. Value	Hours of Use by Enterprise in 1991 b Corn	Corn Sil.	Alf. Est.	Alf. Prod.	Soybean	Other
Tractor	90 HP	75	$6,000	$0	30,550	33,605.0	20	350	9,104	28	5	44	122	12	139
Tractor	140 HP	80	30,000	0	53,610	58,971.0	20	300	16,286	57	14	16	44	23	146
Tractor Used (1982 model)a	140 HP	87	11,930	3,811	33,746	58,971.0	20	300	16,368	101	14	5	15	34	131
Tractor	90 HP	91	32,350	16,000	33,250	36,575.0	20	350	9,403						350
Combine	140 HP	90	77,000	28,531	81,000	89,100.0	15	70	16,207	40				30	0
Chisel Plow	12 FT	88	6,630	4,310	4,150	4,565.0	20	40	2,219	34	6				0
Tandem Disc	19 FT	77	2,500	0	10,150	11,165.0	20	20	2,710						20
Field Cultivator	26 FT	82	6.63	0	9,515	10,466.5	20	32	546	15	3	3		10	1
Grain Drill (1980 model)	12 FT	87	420	231	8,375	9,212.5	25	13	2,045			10			3
Alfalfa Seeder	12 FT	77	3,200	0	4,500	4,950.0	25	10	1,099			10			0
Planter, Corn & Soybeans	20 FT	89	15,090	7,232	16,450	18,095.0	15	75	6,395	42	8			25	0
Rotary Hoe	25 FT	91	3,774	2,399	3,850	4,235.0	20	10	221	5	1			4	0
Cultivator, Corn (8 row)	24 FT	89	8,772	5,703	9,650	10,615.0	15	30	1,019	26	4				0
Cultivator, Soybean (13 row)	22.5 FT	89	3,000	0	3,250	3,575.0	15	15	343					15	0
Sprayer	66 FT	80	2,500	0	4,225	4,647.5	15	15	446	8	2			5	0

Schedule 14.7: Machinery and Equipment Inventory 12/31/91 and Average Annual Use

Ben & Bev Dairyman, Upper Midwest, U. S. A.

				1991	**1992 Replacement**			**Hours of Use by Enterprise in 1991b**							
Description		**Year of**	**Purchase**	**Book**	**Purchase**	**List**	**Useful**	**Ann**	**Salv.**	**Corn**	**Corn Sil.**	**Alf. Est.**	**Alf. Prod.**	**Soybean**	**Other**
	Size	**Purchase**	**Price**	**Value**	**Cost**	**Price**	**Life**	**Use**	**Value**						
Corn Head for Combine	4-36"	90	12,695	3,210	12,695	13,964.5	15	40	1,251	40					0
Soybean Head for Combine	20 FT	90	11,325	3,923	11,325	12,457.5	15	30	1,116					30	0
2 Gravity Box Wagons	300 BU	77	2,400	0	5,600	6,160.0	20	80	642	50				30	0
2 Gravity Box Wagons	300 BU	89	5,407	1,491	5,600	6,160.0	20	80	642	50				30	0
Forage Harvestor		82	8,714	890	10,800	11,880.0	15	60	1,065		20	10	30		0
Pick Up Harvester Head		82	2,100	210	2,610	2,871.0	15	40	524			10	30		0
Two Row For. Har. Head	2-36"	82	4,300	440	5,319	5,850.9	15	20	257		20				0
3 Forage Wagons		80	16,200	0	20,625	22,687.5	15	40	2,178			10	30		0
Swather, Pull Type	14 FT	87	7,653	4,210	8,350	9,185.0	20	62	447			12	50		0
Windrow Inverter		89	3,100	0	3,350	3,685.0	29	10					10		0
Baler		81	8,400	0	8,920	9,812.0	15	65	3,308			10	55		0
3 Baled Hay Wagons		90	4,681	0	6,225	6,847.5	20	65	357			10	55		0
Silage Blower		80	3,200	0	4,025	4,427.5	15	100	397	40	20	10	30		0
Manure Equipment		87	30,894	8,742	37,073	40,780.0	12	200	5,272						200
Feed Handling Equipment		85	20,705	1,438	24,846	27,331.0	15	133	2,624						133
Milking Equipment		84	18,450	3,795	27,675	30,442.0	15	1100	2,923						1100
4WD Pickup Truck		86	13,925	2,420	15,000	16,500.0	15	400	5,000						400
Total				98,986											

a The tractor had a new purchase price of $31,500 in 1982. It was purchased used at the beginning of 1987 for $26,419.

The purchase price listed is the nominal value of $26,419 as of the beginning of 1992. The tractor had 1,250 hours of accumulated use when purchased.

b The total includes the hours of use on set aside, the dairy enterprises, and various and sundry tasks such as weed control around the farmstead.

Schedule 14.8: Annual Business Overhead Costs - Ben & Bev Dairyman, Upper Midwest, U. S. A.

Description	Total Cost	Percent Allocation by Enterprise						
		Corn	Corn Silage	Oats-Alf.Est	Alfalfa	Soybeans	Dairy Cows	Dairy Replacements
Office Expense	$ 1,194	11	1	1	5	8	65	9
Fuel, Lube & Utilities[a]	3,500	11	1	1	5	8	65	9
Maintenance & Repairs[a]								
Bldg.& Improv.	7,165	11	1	1	5	8	65	9
Mach. & Equip.	1,235	11	1	1	5	8	65	9
Real Estate Taxes[b]	3,244						12	6
Farm Insurance[a]	880	11	1	1	5	8	65	9
Interest on Real Estate Loan[b]	14,767						12	6

[a]The costs listed are in addition to the fuel, lube, utilities, repairs, and crop insurance listed as operating costs in the projected CAR estimates.

[b]The opportunity costs on real estate listed in the projected costs and returns for crops implicitly include a return on the investment and real estate taxes. Thus, real estate taxes and interest on the real estate loan are not included in the projected CAR estimates for crops. Approximately 69% of the appraised value of the real estate is for the land, 13% for crop and machinery storage facilities, and 18% for livestock facilities. The estimates in Chapter 13 allocate 12% of taxes to the dairy herd and 6% of the taxes to dairy replacements. The estimates in Chapter 14 compute taxes for machinery and equipment according the formula in footnote t of Table 14.2 (2% of the average of purchase price and salvage value) and do not attempt to allocate the 13% crop share of 1991 taxes. In preparing historic CAR estimates (not included here), Ben and Bev allocate 82% of the real estate taxes and interest on the real estate loan to crops and 18% to the dairy cattle.

APPENDIX 14A

SUPPLEMENTARY DATA TABLES FOR CHAPTER 14

Overview

This appendix contains data tables that support the CAR estimates in Tables 14.1 to 14.4. Table 14A.1 contains machinery and labor data for the production of corn. Table 14A.2 contains the general parameter assumptions and data used to estimate machine and labor costs. Included in the first section are interest and inflation rates, the prices of fuel, and labor costs. The second section contains prices, useful life, annual use, and various engineering coefficients for powers units and implements. Data on fuel type, horsepower, and field capacity are also included. This report assumes that power units operate 10% longer than actual field time, while labor hours are 20% higher than field time. Table 14A.3 calculates salvage (remaining) values for all machinery units. Based on these values, list and purchase prices, and the other parameters, the table then gives estimates of capital recovery, taxes, insurance and shelter, fuel and lube, and repair expenses for each power unit and implement on a per hour basis. Table 14A.4 uses the cost estimates from Table 14A.3 to compute the operating and overhead costs for various machine complements used on the Ben and Bev Dairyman operation. These costs are reported on a per acre basis. Table 14A.5 gives the data and calculations used to compute the field capacity of the various implements used. Table 14A.6 gives detailed calculations for capital recovery for three example pieces of equipment. Table 14A.7 shows the data and calculations used to estimate nominal monthly labor costs. Table 14A.8 presents data on general overhead expenses and how they are allocated to the alternative crops. Table 14A.9 contains machinery and labor cost estimates for the production of soybeans. Table 14A.10 contains machinery and labor information for the establishment of alfalfa with an oats nurse crop.

Data, Assumptions, and Calculations Used for Estimating Machine Costs

Table 14A.2 contains the assumptions used to estimate machine costs. In late 1991, Ben estimated what it would cost him to purchase a new machine to replace each one on his farm. Based on discussions with local extension specialists, a list price 10% higher than this purchase price was used for each machine. One of Ben’s used 140 HP tractors was included in the estimates as an example of how to handle used machines. The useful life of all tractors was assumed to be 20 years. The combine’s expected life was assumed to be 15 years. Most other machines were given an expected life of 15 or 20 years based on discussions with Ben and the experience of John Q. Taskforce. Estimated annual use was based on past use in Ben’s operation. Repair cost factors are from ASAE 1997 while the remaining value factors come from both ASAE 1997 and Cross and Perry (1995, 1996). The latest versions of the Cross-Perry equations given in Table 6.4 were not used since they were not officially in print at the time this report was published.

Field capacities were estimated using equation 5.6, which is repeated here for convenience. Calculated area capacity is computed as

$$C_a = \frac{(S)\,(W)\left(\frac{E_f}{100}\right)}{8.25} \qquad \textbf{(5.6)}$$

where

C_a	=	acres per hour calculated capacity
S	=	implement speed in miles per hour
W	=	measured width of the implement in feet
E_f	=	field efficiency, the ratio of effective accomplishment compared to theoretical accomplishment, expressed in percent
8.25	=	43,560 (square feet per acre) divided by 5,280 (feet per mile) = width of acre 1 mile long.

The efficiency and field speed data are taken from ASAE 1997. Table 14A.5 contains the width, speed, efficiency, and estimated acres per hour for each machine. The forage harvester is a two-part machine including a base unit that is pulled by a tractor and a head which attaches. One head is for cutting row crops such as corn silage, while the other is a platform head for cutting crops such as alfalfa or green oats. The combine also has two heads, one for row crops and one for crops such as soybeans or wheat.

Salvage values (SV) are computed using the formulas in Tables 6.2-6.4 and the coefficients in Table 14A.3. Capital recovery is then based on equation 6.7. The purchase price, not the list price, is used in the calculation. The specific formula is

$$CSC = \frac{\left(PP - \frac{SV}{(1+r)^n}\right)}{\left(\frac{1 - (1+r)^{-n}}{r}\right)}$$

where r is the real interest rate, n is the useful life, and PP is the purchase price. Because this value is based on beginning-of-year prices, it is multiplied by (1.04) to obtain a year-end value. Detailed calculations for three machines are contained in Table 14A.6. Taxes, insurance, and shelter (TIS) are charged at 2% of the average of purchase price and salvage value.

Fuel consumption in gallons per hour is calculated using equation 5.19 which for a diesel engine is

$$Diesel_{gph} = (.06)\ (PTO_{\max})\ (.73)$$

The diesel cost is assumed to be $0.90 per gallon on January 1, 1992. Lubrication is assumed to be 15% of fuel costs.

Cumulative repairs ($C_{rm\,t}$) after h_t hours of use with a list price of P_t are calculated using equations 5.8 and 5.9. Equation 5.8 is repeated here for convenience

$$C_{rm\,t} = (RF1)(P_t)\left(\frac{h_t}{1{,}000}\right)^{RF2}. \qquad \textbf{(5.8)}$$

The coefficients RF1 and RF2 come from ASAE 1997. Equation 5.9 is used to convert this to a cost per hour.

Calculation of Machine Complement Costs

Each field operation requires a specific machine complement, usually a power unit and an implement. The cost to use the complement for a given operation is the cost per hour for each piece of equipment multiplied by their respective field multipliers (1.1 for tractors and combines and 1 for all other implements) and divided by the acres per hour for the implement. This will then give a cost per acre for the operation. Consider, for example, the costs per acre to bale hay. The operation uses the newer 90 HP tractor and the baler. The repair cost per hour for the tractor is $1.86. The repair cost per hour for the baler is $2.30. The field capacity of the baler is 5.09 acres per hour. The repair and maintenance (C_{rm}) cost per acre is then given by

$$\begin{aligned} C_{rm\,per\,acre}(baling) &= \frac{(1.1)(1.86) + (1)(2.30)}{5.09} \\ &\approx 0.85\,. \end{aligned}$$

The fuel and lube (C_{FL}) cost per acre for baling is the fuel and lube cost per hour for the tractor divided by the field capacity of the baler or

$$\begin{aligned} C_{FL\,per\,acre}(baling) &= \frac{(1.1)(4.08)}{5.09} \\ &\approx 0.88\,. \end{aligned}$$

The labor cost per acre is the total number of hours of labor time divided by the field capacity multiplied by the cost per hour for the type of labor used. The more expensive full-time hired man usually bales the hay. With a labor multiplier of 1.2 this will give

$$
\begin{aligned}
C_{Labor\,per\,acre}(baling) &= \left(\frac{1.2}{5.09}\right)(10.023) \\
&\approx 2.36
\end{aligned}
$$

as the cost per acre for labor in baling hay.

The overhead costs per acre are computed in the same fashion as the repair costs by aggregating over the power unit and the implement. For baling this will give a cost of capital recovery or overhead of

$$
\begin{aligned}
C_{CCR\,per\,acre}(baling) &= \frac{(1.1)(8.32) + (1)(13.25)}{5.09} \\
&\approx 4.401\,.
\end{aligned}
$$

The repair costs are in real end-of-year prices. The fuel and lube costs are in beginning-of-year nominal prices. The labor costs are in real end of year prices. The overhead costs are in real end-of-year prices. The overhead costs are only charged at the end of the year and so need no adjustment. The labor costs will need to be deflated to get a nominal labor cost for the month of operation. The fuel costs will need to be inflated to get a nominal cost for the month of operation. The repair costs, though specified in end-of-year terms, will be used as if they were monthly nominal prices for the purpose of computing operating interest. These adjustments will be made in Tables 14A.1, 14A.9, and 14A.10.

Costs of Corn Production

The machinery and labor costs of corn production are computed in Table 14A.1. Each operation is represented by a column in the table. Each activity is represented by a complement number from Table 14A.4. The month of the operation is also specified. Anhydrous is applied in November of the previous year. It was decided to charge the chiseling in the 11th month of the production year rather than the 11th month of the previous year because the chiseling is really a close-out activity for corn production. The acres per hour and hours per acre are listed to make the computations clear. The first cost row lists the fuel and lube cost for the operation in beginning-of-year prices from Table 14A.4 multiplied by times over. The next row lists the repair cost per acre in end-of-year prices from Table 14A.4 multiplied by times over. For most operations, times over is 1, but for the rotary hoe it is 0.3, meaning only 30% of the acres are rotary hoed each year. The times over is larger (1.06) for the chisel plowing because it is performed on crop acres and the set-aside acres while the times over is only 0.06 for the set-aside acres. The next row lists the total labor hours per acre. This is computed by dividing the labor multiplier (1.2) by the field capacity of the machine and then multiplying by the times over for this operation. The total hours per acre are divided according to the labor type from Table 14A.4. These labor costs are in end-of-year prices. The second section of the table adjusts the prices to nominal terms in the month of operation. The first row is for fuel and lubrication. For example, the beginning of year cost for combining corn of \$0.76185 is adjusted to the end of October as follows

$$
\begin{aligned}
C_{F\&L-Nominal}(Combining\ in\ Oct) &= 0.76185\ (1.04)^{\frac{10}{12}} \\
&= 0.78716\,.
\end{aligned}
$$

Labor costs are also adjusted to a current month basis from an end-of-year basis. The cost of applying herbicide is adjusted from an end-of-year value of $0.35711 to $0.34903 at the end of May as follows

$$
\begin{aligned}
C_{Labor-Nominal}(Spraying\ in\ May) &= 0.35711\ (1.04)^{-\frac{7}{12}} \\
&= 0.34903\,.
\end{aligned}
$$

The labor costs are then allocated according to the specifications in Table 14A.4. The operating costs per acre as taken from Table 14A.4 are in the next row while the costs using current month prices (except for repairs) are in the following row. Interest costs (ic) are then computed on each of the three types of expenses, fuel and lube, repairs, and labor. These are computed using equation 2.15 which is repeated here for convenience.

$$ic = R(1+i)^{\frac{n}{12}} - R\,. \qquad \textbf{(2.15)}$$

For example, the interest cost on the labor to field cultivate is computed as

$$
\begin{aligned}
ic_{Labor}(Field\ Cultivate) &= 0.62693(1.092)^{\frac{7}{12}} - 0.62693 \\
&= 0.03303\,.
\end{aligned}
$$

The overhead costs per acre come from Table 14A.4 multiplied by times over. They are in end-of-year terms. The total operating interest is the sum of the operating interest on fuel and lubrication, repairs and labor.

The last column in the table gives the sum for each row over the operations in the columns. The various numbers in the table are then used in different parts of the summary estimates.

Costs of Soybean Production

Table 14.9 is very similar to Table 14.1 which is for corn production. Many of the costs are the same because the same field operations are used.

Costs of Alfalfa Establishment

Table 14.10 is similar to Table 14.1 which is for corn production. Two crops are now planted and harvested. In this case, the revenues occur before the end of the year and so some interest on the revenue accrues. Labor use is higher with the harvesting of two crops and the hauling of hay.

Labor Costs

Table 14A.7 contains detailed data used in constructing labor costs. Data on total labor hours and their allocation from Schedule 14.4 are used to compute an implicit nominal wage for 1991 for the two hired men. The operator valued his time at $9.50 per hour and his son's time at the implicit hired wage for the part-time worker. The wages in the last column are the 1991 wages adjusted for 4% inflation. The hours per enterprise are Ben Dairyman's best estimate of allocations for 1991. The costs per acre are then computed from the total number of hours multiplied by the 1992 wage rate divided by the number of acres grown. This then gives an estimated cost per acre based on Ben's 1991 estimates of hours used. These total labor costs per acre are as follows:

Worker	**Corn Per Acre Nominal Cost**	**Oats-Alf Per Acre Nominal Cost**	**Soybean Per Acre Nominal Cost**
Operator	9.88	9.88	9.88
Son	0	5.644889	0
Hired worker 1	12.2108	9.845333	5.01919
Hired worker 2	1.4662	2.822444	2.26902
Total Hired	13.677	12.66778	7.28821
Total cost per acre 1991 allocations	**23.557**	**28.19267**	**17.1682**
Operator	1.71	4.62	1.71
Son		0.00	
Hired worker 1	9.41	14.09	5.09
Hired worker 2	0.45	2.70	.39
Total cost per acre 1992 machine calculations	**$11.57**	**21.41**	**$7.19**

The calculations using the machinery data are an underestimate of labor used, probably due to the small amount of the operator's time actually devoted to field work. Notice, also, that the son was planning to be away at college in 1992 and so provided no labor.

Monthly nominal labor charges can be computed using the technique suggested in Chapter 2 and discussed in footnote [q] of Table 14.2. The nominal average price for 1991 is adjusted to get a nominal average price for 1992. A real year-end price that will give this nominal average is then obtained from equation 2.35. This is given by

$$
\begin{aligned}
p^r &= \frac{(12)(\bar{p}^n)}{\sum_{j=1}^{12}(1+\pi_m)^{j-12}} \\
&= \frac{(12)(\bar{p}^n)}{(1+\pi_m)\sum_{j=1}^{12}(1+\pi_m)^{(j-12-1)}} \\
&= \frac{(12)(\bar{p}^n)}{(1+\pi_m)US_0(\pi_m,12)} \,.
\end{aligned}
\qquad \textbf{(2.35)}
$$

where π_m is the monthly rate of inflation and $\bar{p}_n$ is the nominal average price. For the case at hand and the operator we obtain

$$
\begin{aligned}
p^{r} &= \frac{(12)(9.88)}{(1.003274)\left(\dfrac{1 - (1.003274)^{-12}}{0.003274}\right)} \\
&= \frac{118.56}{(1.003274)\left(\dfrac{1 - 0.961535}{0.003274}\right)} \\
&= \frac{118.56}{(1.003274)(11.74848)} \\
&= 10.0586\,.
\end{aligned}
$$

The nominal monthly prices are then obtained using equation 2.36 which is repeated here

$$p_j^{n} = p^{r}(1+p_m)^{j-12} \qquad (2.36)$$

where p_j^n is the nominal price in the j^{th} month.

Table 14A.1 Machine and labor costs for corn production

Real Interest rate	0.05					
Inflation rate	0.04					
Nominal Interest Rate	0.092					
Operation Description	Apply Anhydrous	Field Cultivate	Plant Corn	Rotary Hoe	Apply Herbicide	Row Cultivate
Complement #	1	2	3	4	8	5
Complement Description	Apply Anhydrous	Field Cultivate Corn/Oats	Plant corn/soy	Rotary Hoe	Spray	Row Cultivate
Month of Operation	-2	5	5	5	5	6
Field Rate Data						
'Acres Per Hour	9.69697	18.75152	8.66667	29.09091	33.80000	17.45455
'Hours Per Acre	0.10313	0.05333	0.11538	0.03438	0.02959	0.05729
Times Over	1	1	1	0.3	1	1
Fuel & Lube Cost per Acre (Beg Year Prices)	0.71994	0.37230	0.80553	0.04628	0.13278	0.39997
Repair Cost per Acre (End of Year Prices)	0.29220	0.34517	**1.11790**	0.02663	0.09814	**0.27121**
Total Labor Hours Per Acre	0.12375	0.06399	0.13846	0.01238	0.03550	0.06875
Operator Labor Hours Per Acre	0.00000	0.00000	0.13846	0.00000	0.03550	0.00000
Hired 1 Labor Hours Per Acre	0.12375	0.06399	0.00000	0.01238	0.00000	0.00000
Hired 2 Labor Hours Per Acre	0.00000	0.00000	0.00000	0.00000	0.00000	0.06875
Total Labor Cost per Acre (Real End Year Prices)	1.24038	0.64144	1.39273	0.12404	**0.35711**	0.39510
Operator Labor Cost per Acre (Real End Year Prices)			1.39273		0.35711	
Hired 1 Labor Cost per Acre (Real End Year Prices)	1.24038	0.64144		0.12404		
Hired 2 Labor Cost per Acre (Real End Year Prices)						**0.39510**
Fuel & Lube Cost per Acre (Current Month Prices)	0.71525	0.37844	**0.81880**	0.04704	0.13497	**0.40789**
Total Labor Cost per Acre (Current Month Prices)	1.18490	**0.62693**	1.36122	0.12123	**0.34903**	0.38743
Operator Labor Cost per Acre (Current Month Prices)	0.00000	0.00000	**1.36122**	0.00000	0.34903	0.00000
Hired 1 Labor Cost per Acre (Current Month Prices)	1.18490	0.62693	0.00000	0.12123	0.00000	0.00000
Hired 2 Labor Cost per Acre (Current Month Prices)	0.00000	0.00000	0.00000	0.00000	0.00000	**0.38743**
Operating Costs per Acre (Stated Prices)	2.25252	1.35892	3.31616	0.19695	0.58803	1.06628
Operating Costs per Acre (Current Month Except Repairs)	2.19236	1.35054	3.29793	0.19491	0.58214	1.06653
Operating Interest on Fuel & Lube (Current Month Prices)	0.07734	0.01994	**0.04313**	0.00248	0.00711	**0.01835**
Operating Interest on Repairs (End of Year Prices)	0.03160	0.01818	**0.05889**	0.00140	0.00517	**0.01220**
Operating Interest on Labor (Current Month Prices)	0.12813	**0.03303**	**0.07171**	0.00639	0.01839	0.01743
Overhead Costs per Acre (End of Year)	1.77286	2.19510	4.41069	0.46221	1.15914	**2.74456**
Total Cost per Acre (Stated Prices)	4.02538	3.55401	7.72684	0.65916	1.74716	3.81084
Total Cost per Acre (Adjusted Prices)	3.96522	3.54564	7.70861	0.65712	1.74127	3.81109
Total Operating Interest on Above	0.23707	0.07115	0.17374	0.01027	0.03067	0.04798
Total Costs including Interest	4.20229	3.61679	7.88235	0.66739	1.77194	3.85907

Table 14A.1 Machine and labor costs for corn production (continued)

Operation Description	Combine Corn	Haul Corn	Blow Corn	Chisel Plow	Plant Set Aside	Mow Set Aside	Total All Operations
Complement #	6	7	9	10	11	12	
Complement Description	Combine Corn	Haul Corn/Soy	Blow Corn	Chisel Plow	Plant Set-aside	Mow Set-aside	
Month of Operation	10	10	10	11	5	8	
Field Rate Data							
'Acres Per Hour	9.16364	6.00000	6.00000	6.18182	5.09091	6.78788	
'Hours Per Acre	0.10913	0.16667	0.16667	0.16176	0.19643	0.14732	
Times Over	1	1	1	1.06	0.06	0.06	
Fuel & Lube Cost per Acre (Beg Year Prices)	0.76185	1.16355	0.74799	1.19708	0.05289	0.03967	6.43985
Repair Cost per Acre (End of Year Prices)	0.56736	1.13618	0.57523	0.89677	0.03466	0.03542	**5.39688**
Total Labor Hours Per Acre	0.13095	0.20000	0.20000	0.20576	0.01414	0.01061	**1.20430**
Operator Labor Hours Per Acre	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.17396
Hired 1 Labor Hours Per Acre	0.13095	0.20000	0.20000	0.20576	0.01414	0.00000	0.95098
Hired 2 Labor Hours Per Acre	0.00000	0.00000	0.00000	0.00000	0.00000	0.01061	0.07936
Total Labor Cost per Acre (Real End Year Prices)	1.31257	2.00466	2.00466	2.06244	0.14176	0.06096	11.73783
Operator Labor Cost per Acre (Real End Year Prices)							1.74983
Hired 1 Labor Cost per Acre (Real End Year Prices)	1.31257	2.00466	2.00466	2.06244	0.14176		9.53193
Hired 2 Labor Cost per Acre (Real End Year Prices)						0.06096	0.45606
Fuel & Lube Cost per Acre (Current Month Prices)	**0.78716**	1.20220	0.77285	1.24091	0.05377	0.04072	**6.60000**
Total Labor Cost per Acre (Current Month Prices)	1.30402	1.99159	1.99159	2.05571	0.13855	0.06017	11.57238
Operator Labor Cost per Acre (Current Month Prices)	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	1.71025
Hired 1 Labor Cost per Acre (Current Month Prices)	1.30402	1.99159	1.99159	2.05571	0.13855	0.00000	9.41453
Hired 2 Labor Cost per Acre (Current Month Prices)	0.00000	0.00000	0.00000	0.00000	0.00000	0.06017	0.44759
Operating Costs per Acre (Stated Prices)	2.64178	4.30439	3.32788	4.15629	0.22931	0.13604	23.57455
Operating Costs per Acre (Current Month Except Repairs)	2.65854	4.32998	3.33967	4.19338	0.22698	0.13630	23.56926
Operating Interest on Fuel & Lube (Current Month Prices)	0.01163	0.01776	0.01142	0.00913	0.00283	0.00121	**0.22235**
Operating Interest on Repairs (End of Year Prices)	0.00838	0.01679	0.00850	0.00660	0.00183	0.00105	**0.17060**
Operating Interest on Labor (Current Month Prices)	0.01927	0.02943	0.02943	0.01513	0.00730	0.00179	**0.37742**
Overhead Costs per Acre (End of Year)	18.01304	4.43071	2.24225	3.80379	0.72598	0.19128	**42.15160**
Total Cost per Acre (Stated Prices)	20.65482	8.73509	5.57013	7.96008	0.95529	0.32733	65.72616
Total Cost per Acre (Adjusted Prices)	20.67158	8.76069	5.58192	7.99717	0.95296	0.32759	**65.72086**
Total Operating Interest on Above	0.03928	0.06398	0.04935	0.03087	0.01196	0.00406	**0.77037**
Total Costs including Interest	20.71087	8.82467	5.63127	8.02804	0.96492	0.33164	**66.49123**

Stated prices are beginning of year prices for fuel, lube and labor and end of year prices for repairs and overhead
Adjusted prices are in current months for fuel, lube and labor and end of the year for repairs and overhead

Table 14A.2 General assumptions and data used to estimate machinery costs

Interest and inflation rates

Real Interest Rate	0.05	Monthly Real Interest Rate	0.004074
Inflation Rate	0.04	Monthly Inflation Rate	0.003274
Nominal Interest Rate	0.092	Monthly Nominal Int. Rate	0.007361

Fuel Prices	**Type**	**Price**
gas	1	1.275
diesel	2	0.90
LP gas	3	0.65

Wage Rates

Operator (O)	10.05857016
Hired Person 1 (H1)	10.02327693
Hired Person 2 (H2)	5.746914063
Son	5.746914063
Labor Multiplier	1.2

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Assumed values for machinery

Power Unit #	Description	List price	Purchase Price	Useful Life	Previous Use (hrs)	Remain Life (yrs)	Annual use (hrs)	HP	Fuel type (1,2,3)	Remaining Value Factors RV1	RV2	Repair cost Factors RF1	RF2	int	ageco	ageex	hrsco	hrsex	expon
1	90 HP TRACTOR	33605	30550	20	0	20	350	90	2	0.68	0.92	0.007	2.00	0.9769	-0.023	0.76	0	0.6	3.85
2	140 HP TRACTOR	58971	53610	20	0	20	300	140	2	0.68	0.92	0.007	2.00	0.9769	-0.023	0.76	0	0.6	3.85
3	140 HP TRACTOR	58971	33745.86	20	2750	10	300	140	2	0.68	0.92	0.007	2.00	0.9769	-0.023	0.76	0	0.6	3.85
4	90 HP TRACTOR	36575	33250	20	0	20	350	90	2	0.68	0.92	0.007	2.00	0.9769	-0.023	0.76	0	0.6	3.85
5	140 HP COMBINE	89100	81000	15	0	15	70	140	2	0.64	0.885	0.040	2.10	0.9453	-0.0455	0.87	0	0.72	2

Implement Unit #	Description	List price	Purchase Price	Useful Life	Previous Use (hrs)	Remain Life (yrs)	Annual use (hours)	Field capacity (a/hr)	Typical Field Capacity	RV1	RV2	RF1	RF2	int	ageco	ageex	hrsco	hrsex	expon
1	12FT. CHISEL PLOW	4565	4150	20	0	20	40	6.18	6.18	0.6	0.885	0.28	1.4	0.6114	0.47309	-0.95			1.61
2	19 FT. TANDEM DISK	11165	10150	20	0	20	20	11.05	11.05	0.6	0.885	0.18	1.7	0.452	0.60697	-0.85			2.04
3	FLD. CULT., 26 FT.	10467	9515	20	0	20	32	18.75	18.75	0.6	0.885	0.27	1.4						
4	GR. DRILL, 12 FT.	9212.5	8375	25	0	25	13	5.09	5.09	0.6	0.885	0.32	2.1	0.8041	-0.0194	0.89			1.96
5	ALFALFA SEEDER, 12 FT.	4950	4500	25	0	25	10	5.09	5.09	0.6	0.885	0.32	2.1	0.8041	-0.0194	0.89			1.96
6	PLANTER, 8 row narrow	18095	16450	15	0	15	75	8.67	8.67	0.6	0.885	0.32	2.1	0.8041	-0.0194	0.89			1.96
7	ROTARY HOE, 25 FT.	4235	3850	20	0	20	10	29.09	29.09	0.6	0.885	0.23	1.4						
8	CULTIVATOR, 8 row (36")	10615	9650	15	0	15	30	17.45	17.45	0.6	0.885	0.17	2.2						
9	CULTIVATOR, 13 skip-row (18")	3575	3250	15	0	15	15	10.91	10.91	0.6	0.885	0.17	2.2						
10	SPRAYER, 66 FT.	4647.5	4225	15	0	15	15	33.80	33.80	0.6	0.885	0.41	1.3						
11	CORN HEAD, 8 row (36")	13965	12695	15	0	15	40	9.16	9.16	0.56	0.885	0.12	2.3						
12	GR. PLAT., SB 20 FT.	12458	11325	15	0	15	30	5.09	5.09	0.56	0.885	0.12	2.3						
13	HAUL GRAIN, 4 300 BU Wagons	12320	11200	20	0	20	80	6.00	6.00	0.6	0.885	0.19	1.3						
14	SILAGE HARVESTER	11880	10800	15	0	15	60	-	-	0.56	0.885	0.15	1.6						
15	SILAGE HARV, platform (14')	2871	2610	15	0	15	40	3.56	3.56	0.56	0.885	0.15	1.6						
16	SILAGE HARV, 2 row	5850.9	5319	15	0	15	20	1.53	1.53	0.56	0.885	0.15	1.6						
17	HAUL SILAGE, 14 ft	22688	20625	15	0	15	40	2.00	2.00	0.6	0.885	0.16	1.6						
18	MOW. CONDIT., 14 FT.	9185	8350	20	0	20	62	6.79	6.79	0.56	0.885	0.18	1.6						
19	WINDROW INVERTER	3685	3350	20	0	20	10	8.15	8.15	0.6	0.885	0.17	1.4						
20	SQ. BALER, 14 FT.	9812	8920	15	0	15	65	5.09	5.09	0.56	0.885	0.23	1.8	0.9543	-0.0594	0.57			2.78
21	HAUL HAY, 15 FT.	6847.5	6225	20	0	20	65	4.00	4.00	0.6	0.885	0.19	1.3						
22	GRAIN AUGER	2100	1890	12	0	12	10	5.38	5.38	0.56	0.885	0.22	1.8						
23	FORAGE BLOWER, 14 FT.	4427.5	4025	15	0	15	100	6.00	6.00	0.56	0.885	0.22	1.8						
24	ANHYDROUS APPLICATOR							9.70	9.697										

Table 14A.3 Costs of operating various tractors and implements for the Dairyman farm

Power Unit #	Description	Salvage Value C-P	Salvage Value ASAE	C-P Capital Recovery	ASAE Capital Recovery	Taxes, ins., shelter	Total overhead costs	Fuel	Lube	Prior Repairs	Cum Repairs (life)	Repairs per year	Total F&L costs	Total operating costs	Total costs	Overhead Costs per Hr.	F&L Costs per Hr.	Repair Costs per Hr	Operating Costs per Hr.
1	90 HP TRACTOR	9104.26	4311.907	2263	2414	412	2676	1242	186	0	11988	599	1428	2027	4703	7.64	4.08	1.71	5.79
2	140 HP TRACTOR	16286.2	7566.655	3962	4236	727	4689	1656	248	0	15455	773	1904	2677	7365	15.63	6.35	2.58	8.92
3	140 HP TRACTOR	16367.6	7566.655	3192	3919	521	3713	1656	248	3247	14194	1095	1904	2999	6712	12.38	6.35	3.65	10.00
4	90 HP TRACTOR	9908.89	4692.992	2463	2627	449	2912	1242	186	0	13047	652	1428	2080	4992	8.32	4.08	1.86	5.94
5	140 HP COMBINE	16207	9124.451	7335	7676	1011	8346	386	58	0	4106	274	444.26	718	9064	119.22	6.35	3.91	10.26

Implement Unit #	Description	Salvage Value P-C	Salvage Value ASAE	P-C Capital Recovery	ASAE Capital Recovery	Taxes, ins., shelter	Total overhead costs	Prior Repairs	Cum Repairs (life)	Repairs per year	Total Costs	Overhead Costs per Hr.	Repair Costs per Hr.	Total Costs per Hr.
1	12FT. CHISEL PLOW	2218.75	237.9345	277	339	66	343	0	973	49	391	8.57	1.22	9.7852
2	19 FT. TANDEM DISK	2709.89	581.9362	762	829	134	896	0	440	22	918	44.78	1.10	45.878
3	FLD. CULT., 26 FT.	NA	545.5294	NA	777	105	882	0	1573	79	960	27.55	2.46	30.006
4	GR. DRILL, 12 FT.	2044.69	260.6817	573	612	108	682	0	289	12	693	52.45	0.89	53.337
5	ALFALFA SEEDER, 12 FT.	1098.64	140.0678	308	329	58	366	0	90	4	370	36.63	0.36	36.993
6	PLANTER, 8 row narrow	6395.17	1737.236	1340	1564	238	1578	0	7712	514	2092	21.03	6.86	27.89
7	ROTARY HOE, 25 FT.	NA	220.7344	NA	314	42	357	0	106	5	362	35.67	0.53	36.201
8	CULTIVATOR, 8 row (36")	NA	1019.108	NA	918	111	**1029**	0	324	22	1050	**34.29**	0.72	35.011
9	CULTIVATOR, 13 skip-row (18")	NA	343.223	NA	309	37	346	0	24	2	348	23.10	0.11	23.203
10	SPRAYER, 66 FT.	NA	446.1899	NA	402	49	450	0	285	19	469	30.03	1.27	31.294
11	CORN HEAD, 8 row (36")	NA	1251.303	NA	1212	145	1357	0	538	36	1393	33.92	0.90	34.815
12	GR. PLAT., SB 20 FT.	NA	1116.267	NA	1081	129	1210	0	248	17	1227	40.34	0.55	40.894
13	HAUL GRAIN, 4 300 BU Wagons	NA	642.1365	NA	914	123	1038	0	4485	224	1262	12.97	2.80	15.773
14	SILAGE HARVESTER	NA	1064.519	NA	1031	123	1154	0	1566	104	1259	19.24	1.74	20.976
15	SILAGE HARV, platform (14')	NA	257.2588	NA	249	30	279	0	198	13	292	6.97	0.33	7.303
16	SILAGE HARV, 2 row	NA	524.2757	NA	508	61	568	0	133	9	577	28.42	0.44	28.865
17	HAUL SILAGE, 14 ft	NA	2178.146	NA	1962	237	2199	0	1667	111	2310	54.97	2.78	57.747
18	MOW. CONDIT., 14 FT.	NA	446.82	NA	683	91	774	0	2426	121	896	12.49	1.96	14.444
19	WINDROW INVERTER, 14 FT.	NA	192.0676	NA	274	37	310	0	68	3	314	31.04	0.34	31.378
20	SQ. BALER, 14 FT.	3307.9	879.2141	734	851	127	861	0	2242	149	1011	13.25	2.30	15.554
21	HAUL HAY, 15 FT.	NA	356.9018	NA	508	68	577	0	1903	95	672	8.87	1.46	10.336
22	GRAIN AUGER	NA	271.473	NA	204	22	227	0	11	1	227	22.65	0.09	22.739
23	FORAGE BLOWER, 14 FT.	NA	396.7306	NA	384	46	430	0	2102	140	570	4.30	1.40	5.7027
24	ANHYDROUS APPLICATOR	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

Table 14A.4 Costs of operating machine complements the Dairyman farm

Complement Unit #	Power Unit #	Implement Unit #	Implement Unit #	Repair Costs per Ac	Fuel& Lube Costs per Ac	Labor Costs per Ac	Operating Costs per Ac	Overhead Costs per Ac	Total Cost per Ac	Operation	Labor Type	Labor Code
1	2	24		0.2922	0.7199	1.2404	2.2525	$1.773	$4.025	Apply Anhydrous	H1	2
2	3	3		0.3452	0.3723	0.6414	1.3589	$2.195	$3.554	Field Cultivate Corn/Oats	H1	2
3	2	6		**1.1179**	**0.8055**	**1.3927**	3.3162	$4.411	$7.727	Plant corn/soy	O	1
4	4	7		0.0888	0.1543	0.4135	0.6565	$1.541	$2.197	Rotary Hoe	H1	2
5	3	8		**0.2712**	0.4000	**0.3951**	1.0663	**$2.745**	$3.811	Row Cultivate	H2	3
6	5	11		0.5674	0.7618	1.3126	2.6418	$18.013	$20.655	Combine Corn	H1	2
7	3	13		1.1362	1.1635	2.0047	4.3044	$4.431	$8.735	Haul Corn/Soy	H1	2
8	4	10		0.0981	0.1328	0.3571	0.5880	$1.159	$1.747	Spray	O	1
9	4	23		0.5752	0.7480	2.0047	3.3279	$2.242	$5.570	Blow Corn	H1	2
10	3	1		0.8460	1.1293	1.9457	3.9210	$3.588	$7.510	Chisel Plow	H1	2
11	4	4		0.5776	0.8816	2.3626	3.8218	$12.100	$15.922	Plant Set-aside	H1	2
12	4	18		0.5903	0.6612	1.0160	2.2674	$3.188	$5.455	Mow Set-aside	H2	3
13	2	3		0.2822	0.3723	0.6414	1.2960	$2.386	$3.682	Field Cultivate Soy	H1	2
14	2	9		0.2694	0.6400	0.6322	1.5415	$3.693	$5.235	Cultivate Soy	H2	3
15	5	12		0.9532	1.3713	2.3626	4.6871	$33.686	$38.373	Combine Soy	H1	2
16	4	4		0.5776	0.8816	2.3709	3.8302	$12.100	$15.930	Plant oats	O	1
17	4	5		0.4732	0.8816	2.3709	3.7257	$8.994	$12.719	Plant alfalfa	O	1
18	4	18		0.5903	0.6612	1.7720	3.0234	$3.188	$6.211	Cut Oats	H1	2
19	2	15	14	1.3758	1.9590	3.3752	6.7100	$12.179	$18.889	Chop Oats	H1	2
20	4	17		2.4144	2.2440	6.0140	10.6724	$32.060	$42.732	Haul Oatlage	H1	2
21	3	23		0.9025	1.1635	2.0047	4.0707	$2.986	$7.057	Blow Oatlage	H1	2
22	4	18		0.5903	0.6612	1.0160	2.2674	$3.188	$5.455	Cut Alfalfa	H2	3
23	4	20		0.8545	0.8816	2.3626	4.0987	$4.401	$8.500	Bale Hay	H1	2
24	2	21		1.0743	1.7453	1.7241	4.5437	$6.516	$11.060	Haul Hay	H2	3

Table 14A.5 Field Capacities of Various Machines

Description	Width	Speed	Efficiency	Acres per Hour	Notes
12FT. CHISEL PLOW	12	5	0.85	6.1818	15' Coulter Chisel
19 FT. TANDEM DISK	19	6	0.8	11.0545	19' Tandem
FLD. CULT., 26 FT.	26	7	0.85	18.7515	
GR. DRILL, 12 FT.	12	5	0.7	5.0909	
ALFALFA SEEDER, 12 FT.	12	5	0.7	5.0909	
PLANTER, 8 row narrow	20	5.5	0.65	8.6667	8-30"
ROTARY HOE, 25 FT.	25	12	0.8	29.0909	
CULTIVATOR, 8 row (36")	36	5	0.8	17.4545	8-36'
CULTIVATOR, 13 skip-row (18")	22.5	5	0.8	10.9091	12-30"
SPRAYER, 66 FT.	66	6.5	0.65	33.8000	
CORN HEAD, 8 row (36")	36	3	0.7	9.1636	8 Row
GR. PLAT., SB 20 FT.	20	3	0.7	5.0909	20' Grain Platform
HAUL GRAIN, 4 300 BU Wagons				6.0000	
SILAGE HARVESTER					Forage Chopper (Base unit)
SILAGE HARV, platform (14')	14	3	0.7	3.5636	Forage Chopper for Oatlage & Haylage
SILAGE HARV, 2 row	6	3	0.7	1.5273	Silage Harvesting Head for Corn
HAUL SILAGE, 14 ft				2.0000	
MOW. CONDIT., 14 FT.	14	5	0.8	6.7879	
WINDROW INVERTER	14	6	0.8	8.1455	Uses Data on Rake
SQ. BALER, 14 FT.	14	4	0.75	5.0909	Small Baler with Twine
HAUL HAY, 15 FT.				4.0000	
GRAIN AUGER 6"				5.3846	Grain Auger (700 Bu per hour)
FORAGE BLOWER, 14 FT.				6.0000	
ANHYDROUS APPICATOR	20	5	0.8	9.6970	

Table 14A.6 Example Calculations for Captial Recovery for Tractors and Machinery

	140 HP Tractor				**140 HP Used Tractor**				**Row Cultivator**			
Vo	53610.0000				33745.8588				9650.0000			
Vn	16286.2483				16367.5876				1019.1082			
Vo - Vn	37323.7517				17378.2712				8630.8918			
n	20				10				15			
Real interest rate	0.0500				0.0500				0.0500			
Inflation rate	0.0400				0.0400				0.0400			
Nominal interest rate	0.0920				0.0920				0.0920			
Vn/((1+r)^n)	6138.1157				10048.2789				490.2085			
V0-(Vn/((1+r)^n))	47471.8843				23697.5799				9159.7915			
US0(n,r)	12.46221				7.721734929				7.7217349			
Real annuity	3809.2668				3068.9450				882.4753			
Inflation adjusted annuity	3961.6375				3191.7028				917.7743			
End of Year	**Actual**	**PV**	**Annuity**	**PV Annuity**	**Actual**	**PV**	**Annuity**	**PV Annuity**	**Actual**	**PV**	**Annuity**	**PV Annuity**
0	53610.000	53610.000			33745.859	33745.859			9650.000	9650.000		
1	0.000	0.000	3961.64	3627.873156	0.000	0.000	3191.70	2922.80477	0.000	0.000	917.77	840.4526368
2	0.000	0.000	3961.64	3455.117292	0.000	0.000	3191.70	2783.62359	0.000	0.000	917.77	800.4310827
3		0.000	3961.64	3290.587897		0.000	3191.70	2651.07009		0.000	917.77	762.3153169
4		0.000	3961.64	3133.893235		0.000	3191.70	2524.82865		0.000	917.77	726.0145875
5		0.000	3961.64	2984.660224		0.000	3191.70	2404.59872		0.000	917.77	691.4424643
6		0.000	3961.64	2842.533547		0.000	3191.70	2290.09402		0.000	917.77	658.5166326
7		0.000	3961.64	2707.174806		0.000	3191.70	2181.04192		0.000	917.77	627.1586977
8		0.000	3961.64	2578.26172		0.000	3191.70	2077.18278		0.000	917.77	597.2939979
9		0.000	3961.64	2455.487353		0.000	3191.70	1978.26932		0.000	917.77	568.8514265
10		0.000	3961.64	2338.559384	-17022.291	-10048.279	3191.70	1884.06602		0.000	917.77	541.7632634
11		0.000	3961.64	2227.199413				0		0.000	917.77	515.9650127
12		0.000	3961.64	2121.142298				0		0.000	917.77	491.3952502
13		0.000	3961.64	2020.135522				0		0.000	917.77	467.9954764
14		0.000	3961.64	1923.938592				0		0.000	917.77	445.7099775
15		0.000	3961.64	1832.322469				0	-1059.873	-490.208	917.77	424.4856929
16		0.000	3961.64	1745.069018				0				
17		0.000	3961.64	1661.970493				0				
18		0.000	3961.64	1582.829041				0				
19		0.000	3961.64	1507.45623				0				
20	-16937.698	-6138.116	3961.64	1435.6726				0				
PV0		47471.884		47471.8843		23697.580		23697.580		9159.792		9159.792

Table 14A.7 Labor Use and Cost for Operations

Real interest rate	0.05
Inflation rate	0.04
Nominal interest arate	0.092
Monthly inflation rate	0.0032737
Acres of Corn	154
Acres of Soybean	102
Acres of Alfalfa Estab.	30
Acres of Alfalfa	83
Acres of Corn Silage	27
ARP	7.55

Labor costs based on 1991 allocations

Worker	**Total Hours**	**Total Crop Hours**	**Corn Hours**	**Corn Per Acre Cost**	**Silage Hours**	**Silage Per Acre Cost**	**Oats-Alf Hours**	**Oats-Alf Per Acre Cost**	**Alfalfa Hours**	**Alfalfa Per Acre Cost**	**Soy Hours**	**Soybean Per Acre Cost**	**ARP Hours**	**ARP Per Acre Cost**	**Overhead Hours**	**Wages $/hour 1991**	**Wages $/hour 1992**
Operator	3,550	1,113	154	9.88	27	9.88	30	9.88	80	9.52289	102	9.88	0	0	720	$9.50	9.880
Spouse	30		0	0	0	0	0	0	0	0	0	0	0	0	30		
Son	460	0	0	0	0	0	30	5.644889	100	6.80107	0	0	0	0	0	$5.43	5.645
Hired worker 1	2,550	1,956	191	12.2108	54	19.6907	30	9.845333	45	5.33783	52	5.01919	5	6.52009	0	$9.47	9.845
Hired worker 2	900	661	40	1.4662	14	2.92698	15	2.822444	45	3.06048	41	2.26902	11	8.22434	0	$5.43	5.645
Total Hired	3450	2617	231	13.677	68	22.6176	45	12.66778	90	8.39831	93	7.28821	16	14.7444	0		
Total cost per acre				**23.557**		**32.4976**		**28.19267**		**24.7223**		**17.1682**		**14.7444**			

Labor wages per month

Item	**Real Price Year**	**Jan 1**	**Feb 2**	**Mar 3**	**Apr 4**	**May 5**	**Jun 6**	**July 7**	**Aug 8**	**Sep 9**	**Oct 10**	**Nov 11**	**Dec 12**	**Average**	**Last year nominal**	**Current nominal**
Operator labor real	**10.058570**	10.0586	10.0586	10.0586	10.0586	10.0586	10.0586	10.0586	10.0586	10.0586	10.0586	10.0586	10.0586	10.0586	9.5000	9.8800
Operator labor nominal		9.7034	9.7351	9.7670	9.7990	9.8311	9.8632	**9.8955**	9.9279	9.9604	9.9930	10.0257	10.0586	9.8800	9.5000	9.8800
Hired labor 1 real	**10.023277**	10.0233	10.0233	10.0233	10.0233	10.0233	10.0233	10.0233	10.0233	10.0233	10.0233	10.0233	10.0233	10.0233	9.4667	9.8453
Hired labor 1 nominal		9.6693	9.7010	9.7327	9.7646	9.7966	9.8286	9.8608	9.8931	9.9255	9.9580	9.9906	10.0233	9.8453	9.4667	9.8453
Hired labor 2 real	**5.746914**	5.7469	5.7469	5.7469	5.7469	5.7469	5.7469	5.7469	5.7469	5.7469	5.7469	5.7469	5.7469	5.7469	5.4278	5.6449
Hired labor 2 nominal		5.5440	5.5621	5.5803	5.5986	5.6169	5.6353	5.6538	5.6723	5.6908	5.7095	5.7282	5.7469	5.6449	5.4278	5.6449

Table 14A.8 Insurance and overhead costs for corn production

Acres of Corn	154
Acres of Soybean	102
Acres of Alfalfa Establishment	30
Alfalfa	83
Corn Silage	27
ARP	7.55
Annual inflation rate	0.04

Overhead expenses	Total 1991	Total 1992	Corn %	Corn Total	Corn Per Acre	Soybean %	Soybean Total	Soybean Per Acre	Alf-Oats %	Alf-Oats Total	Alf-Oats Per Acre
Office	1194	1241.76	0.11	136.59	0.89	0.08	99.34	0.97	0.01	12.42	0.41
Fuel, Lube and Utilities	3500	3640	0.11	400.40	2.60	0.08	291.20	2.85	0.01	36.40	1.21
Bldg Repairs	7165	7451.6	0.11	819.68	5.32	0.08	596.13	5.84	0.01	74.52	2.48
Machinery Repairs	1235	1284.4	0.11	141.28	0.92	0.08	102.75	1.01	0.01	12.84	0.43
Total Overhead	13094	13617.76		1497.954	9.73		1089.42	10.68		136.178	4.54
Insurance	880	915.2	0.11	100.67	0.65	0.08	73.22	0.72	0.01	9.15	0.31

Table 14A.9 Machine and labor costs for soybean production

Real Interest rate	0.05
Inflation rate	0.04
Nominal Interest Rate	0.092

Operation Description	Field Cultivate	Plant Soybean	Rotary Hoe	Apply Herbicide	Row Cultivate	Combine Soybean	Haul Soybean	Total All Operations
Complement #	13	3	4	8	5	15	7	
Complement Description	Field Cultivate Soy	Plant corn/soy	Rotary Hoe	Spray	Row Cultivate	Combine Soy	Haul Corn/Soy	
Month of Operation	5	5	5	6	6	10	10	
Field Rate Data								
'Acres Per Hour	18.75152	8.66667	29.09091	33.80000	17.45455	5.09091	6.00000	
'Hours Per Acre	0.05333	0.11538	0.03438	0.02959	0.05729	0.19643	0.16667	0.65306
Times Over	1	1	0.3	1	1	1	1	
Fuel & Lube Cost per Acre (Beg Year Prices)	0.37230	0.80553	0.04628	0.13278	0.39997	1.37132	1.16355	4.29174
Repair Cost per Acre (End of Year Prices)	0.28221	1.11790	0.02663	0.09814	**0.27121**	0.95319	1.13618	**3.88547**
Total Labor Hours Per Acre	0.06399	0.13846	0.01238	0.03550	0.06875	0.23571	0.20000	**0.75480**
Operator Labor Hours Per Acre	0.00000	0.13846	0.00000	0.03550	0.00000	0.00000	0.00000	0.17396
Hired 1 Labor Hours Per Acre	0.06399	0.00000	0.01238	0.00000	0.00000	0.23571	0.20000	0.51208
Hired 2 Labor Hours Per Acre	0.00000	0.00000	0.00000	0.00000	0.06875	0.00000	0.00000	0.06875
Total Labor Cost per Acre (Real End Year Prices)	0.64144	1.39273	0.12404	0.35711	0.39510	2.36263	2.00466	7.27770
Operator Labor Cost per Acre (Real End Year Prices)				0.35711				0.35711
Hired 1 Labor Cost per Acre (Real End Year Prices)	0.64144	1.39273	0.12404			2.36263	2.00466	6.52549
Hired 2 Labor Cost per Acre (Real End Year Prices)					**0.39510**			0.39510
Fuel & Lube Cost per Acre (Current Month Prices)	0.37844	0.81880	0.04704	0.13541	**0.40789**	1.41688	1.20220	**4.40668**
Total Labor Cost per Acre (Current Month Prices)	0.62693	1.36122	0.12123	0.35017	0.38743	2.34724	1.99159	7.18582
Operator Labor Cost per Acre (Current Month Prices)	0.00000	1.36122	0.00000	0.35017	0.00000	0.00000	0.00000	1.71140
Hired 1 Labor Cost per Acre (Current Month Prices)	0.62693	0.00000	0.12123	0.00000	0.00000	2.34724	1.99159	5.08699
Hired 2 Labor Cost per Acre (Current Month Prices)	0.00000	0.00000	0.00000	0.00000	**0.38743**	0.00000	0.00000	0.38743
Operating Costs per Acre (Stated Prices)	1.29596	3.31616	0.19695	0.58803	1.06628	4.68714	4.30439	15.45490
Operating Costs per Acre (Current Month Except Repairs)	1.28758	3.29793	0.19491	0.58372	1.06653	4.71731	4.32998	15.47796
Operating Interest on Fuel & Lube (Current Month Prices)	0.01994	0.04313	0.00248	0.00609	**0.01835**	0.02094	0.01776	**0.12869**
Operating Interest on Repairs (End of Year Prices)	0.01487	0.05889	0.00140	0.00441	**0.01220**	0.01408	0.01679	**0.12265**
Operating Interest on Labor (Current Month Prices)	0.03303	0.07171	0.00639	0.01575	0.01743	0.03468	0.02943	**0.20842**
Overhead Costs per Acre (End of Year)	2.38588	4.41069	0.46221	1.15914	**2.74456**	33.68565	4.43071	**49.27883**
Total Cost per Acre (Stated Prices)	3.68184	7.72684	0.65916	1.74716	3.81084	38.37279	8.73509	64.73373
Total Cost per Acre (Adjusted Prices)	3.67346	7.70861	0.65712	1.74286	3.81109	38.40295	8.76069	**64.75679**
Total Operating Interest on Above	0.06783	0.17374	0.01027	0.02626	0.04798	0.06971	0.06398	**0.45976**
Total Costs including Interest	3.74129	7.88235	0.66739	1.76912	3.85907	38.47266	8.82467	**65.21655**

Stated prices are beginning of year prices for fuel, lube and labor and end of year prices for repairs and overhead

Adjusted prices are in current months for fuel, lube and labor and end of the year for repairs and overhead

Table 14A.10 Machine and labor costs for alfalfa establishment after corn

Real Interest rate	0.05					
Inflation rate	0.04					
Nominal Interest Rate	0.092					
Operation Description		Field Cultivate	Plant Oats	Plant Alfalfa	Cut Oats	Chop Oats
Complement #		2	16	17	18	19
Complement Description		Field Cultivate Corn/Oats	Plant oats	Plant alfalfa	Cut Oats	Chop Oats
Month of Operation		4	4	4	5	5
Field Rate Data						
'Acres Per Hour		18.75152	5.09091	5.09091	6.78788	3.56364
'Hours Per Acre		0.05333	0.19643	0.19643	0.14732	0.28061
Times Over		1	1	1	1	1
Fuel & Lube Cost per Acre (Beg Year Prices)		0.37230	0.88156	0.88156	0.66117	1.95903
Repair Cost per Acre (End of Year Prices)		0.34517	0.57765	**0.47315**	**0.59025**	1.37580
Total Labor Hours Per Acre		0.06399	0.23571	0.23571	0.17679	0.33673
Operator Labor Hours Per Acre		0.00000	0.23571	0.23571	0.00000	0.00000
Hired 1 Labor Hours Per Acre		0.06399	0.00000	0.00000	0.17679	0.33673
Hired 2 Labor Hours Per Acre		0.00000	0.00000	0.00000	0.00000	0.00000
Total Labor Cost per Acre (Real End Year Prices)		0.64144	2.37095	2.37095	1.77197	3.37519
Operator Labor Cost per Acre (Real End Year Prices)				2.37095	1.77197	
Hired 1 Labor Cost per Acre (Real End Year Prices)		0.64144	2.37095			3.37519
Hired 2 Labor Cost per Acre (Real End Year Prices)						
Fuel & Lube Cost per Acre (Current Month Prices)		0.37720	0.89317	**0.89317**	**0.67207**	1.99131
Total Labor Cost per Acre (Current Month Prices)		0.62488	2.30976	2.30976	1.73189	3.29884
Operator Labor Cost per Acre (Current Month Prices)		0.00000	2.30976	2.30976	0.00000	0.00000
Hired 1 Labor Cost per Acre (Current Month Prices)		0.62488	0.00000	0.00000	1.73189	3.29884
Hired 2 Labor Cost per Acre (Current Month Prices)		0.00000	0.00000	0.00000	0.00000	0.00000
Operating Costs per Acre (Stated Prices)		1.35892	3.83016	3.72567	3.02340	6.71001
Operating Costs per Acre (Current Month Except Repairs)		1.34726	3.78057	3.67608	2.99421	6.66595
Operating Interest on Fuel & Lube (Current Month Prices)		0.02279	0.05397	**0.05397**	**0.03540**	0.10490
Operating Interest on Repairs (End of Year Prices)		0.02086	0.03491	**0.02859**	**0.03109**	0.07248
Operating Interest on Labor (Current Month Prices)		0.03776	0.13958	**0.13958**	**0.09124**	0.17378
Overhead Costs per Acre (End of Year)		2.19510	12.09971	8.99373	3.18804	12.17896
Total Cost per Acre (Stated Prices)		3.55401	15.92987	12.71940	6.21144	18.88897
Total Cost per Acre (Adjusted Prices)		3.54236	15.88028	12.66981	6.18225	18.84491
Total Operating Interest on Above		0.08141	0.22846	0.22214	0.15774	0.35116
Total Costs including Interest		3.62377	16.10874	12.89195	6.33999	19.19607

Table 14A.10 Machine and labor costs for alfalfa establishment after corn (continued)

Operation Description	Blow Oatlage	Cut Alfalfa	Bale Hay	Haul Bales	Total All Operations
Complement #	21	22	23	24	
Complement Description	Blow Oatlage	Cut Alfalfa	Bale Hay	Haul Hay	
Month of Operation	5	8	8	8	
Field Rate Data					
'Acres Per Hour	6.00000	6.78788	5.09091	4.00000	
'Hours Per Acre	0.16667	0.14732	0.19643	0.25000	
Times Over	1	1	1	1	
Fuel & Lube Cost per Acre (Beg Year Prices)	1.16355	0.66117	0.88156	1.74532	11.45123
Repair Cost per Acre (End of Year Prices)	0.90253	0.59025	0.85451	1.07433	**9.19808**
Total Labor Hours Per Acre	0.20000	0.17679	0.23571	0.30000	**2.56144**
Operator Labor Hours Per Acre	0.00000	0.00000	0.00000	0.00000	0.47143
Hired 1 Labor Hours Per Acre	0.20000	0.00000	0.23571	0.00000	1.61323
Hired 2 Labor Hours Per Acre	0.00000	0.17679	0.00000	0.30000	0.47679
Total Labor Cost per Acre (Real End Year Prices)	2.00466	1.01597	2.36263	1.72407	23.65179
Operator Labor Cost per Acre (Real End Year Prices)			2.36263		6.50555
Hired 1 Labor Cost per Acre (Real End Year Prices)	2.00466	1.01597		1.72407	11.13227
Hired 2 Labor Cost per Acre (Real End Year Prices)					6.01397
Fuel & Lube Cost per Acre (Current Month Prices)	1.18272	0.67869	0.90492	1.79156	**11.66575**
Total Labor Cost per Acre (Current Month Prices)	1.95931	1.00278	2.33194	1.70168	**23.14878**
Operator Labor Cost per Acre (Current Month Prices)	0.00000	0.00000	0.00000	0.00000	**4.61952**
Hired 1 Labor Cost per Acre (Current Month Prices)	1.95931	0.00000	2.33194	0.00000	**15.82481**
Hired 2 Labor Cost per Acre (Current Month Prices)	0.00000	1.00278	0.00000	1.70168	**2.70446**
Operating Costs per Acre (Stated Prices)	4.07074	2.26740	4.09870	4.54372	44.30110
Operating Costs per Acre (Current Month Except Repairs)	4.04456	2.27172	4.09137	4.56757	44.01262
Operating Interest on Fuel & Lube (Current Month Prices)	0.06231	0.02021	0.02694	0.05334	**0.55400**
Operating Interest on Repairs (End of Year Prices)	0.04755	0.01757	0.02544	0.03198	**0.43767**
Operating Interest on Labor (Current Month Prices)	0.10322	0.02985	0.06943	0.05066	**1.14475**
Overhead Costs per Acre (End of Year)	2.98591	3.18804	4.40111	6.51599	**87.80652**
Total Cost per Acre (Stated Prices)	7.05664	5.45544	8.49981	11.05971	132.10762
Total Cost per Acre (Adjusted Prices)	7.03047	5.45976	8.49248	11.08355	**131.81914**
Total Operating Interest on Above	0.21307	0.06763	0.12181	0.13598	**2.13641**
Total Costs including Interest	7.24354	5.52739	8.61429	11.21954	**133.95555**

Stated prices are beginning of year prices for fuel, lube and labor and end of year prices for repairs and overhead
Adjusted prices are in current months for fuel, lube and labor and end of the year for repairs and overhead

CHAPTER 15

EXAMPLES OF COST AND RETURN ESTIMATES: COTTON–ALMOND FARM IN SAN JOAQUIN VALLEY, CALIFORNIA – 1992

The purpose of this chapter is to provide an example of the types of information and supporting schedules needed to estimate costs and returns (CARs) for complex multiyear enterprises. Whereas Chapter 14 provided extensive computational detail in order to illustrate the concepts presented in this handbook, this chapter concentrates on the description of the operations necessary to grow cotton and almonds in California. This chapter also provides an example of a composite or representative projected cost estimate based, not on any particular operation, but on a synthetically constructed operation. The format of presentation is similar to that used by the University of California.

The assumptions in this chapter pertain to sample costs of cotton and almond production in San Joaquin Valley. Practices described should not be considered recommendations by the University of California, but rather represent production procedures considered typical for a well-managed field and row crop farm and orchard in this area. Cultural practices vary by grower and region; variations can be significant. The practices and inputs used in this cost study serve only as a sample or guide. These costs are represented on an annual, per acre basis. *The use of trade names in this report does not constitute an endorsement or recommendation by the University of California nor is any criticism implied by omission of other similar products.*

FARM DESCRIPTION

The hypothetical farm used to develop the projected CARs consists of 1,300 acres in the San Joaquin Valley in California. The farm consists of 500 acres of cotton grown in rotation with 690 acres of other field crops or Acreage Reserve (ACR) land, and 95 acres of almonds. The remaining 15 acres are used for buildings, roads, and burn. The cotton is grown on several fields that are roughly 60 acres in size. The almonds are grown on 40-50 acre blocks. In this study, the almond land is owned and the cotton ground is rented with a cash rent arrangement. Water is supplied by a water irrigation district and wells.

Generally cotton is grown three out of five years and not more than any two years in a row. Possible rotations include (1) cotton–cotton–tomato–cotton–barley, and (2) cotton–cotton–wheat/corn double crop–cotton–wheat/corn double crop. Alternatively, cotton can be rotated with alfalfa seed that would be in the ground for two to three years.

The farm in this study participates in the government commodity program for cotton. This means that 10% of the cotton base must be put into ACR in order to be eligible for full benefits. Typically growers do not pick one field and use it for ACR. Instead a grower will pick weak areas of several fields and put attention to them in terms of soil amendments and weed control. There are various options available for treatment of ACR land: (1) The land can be left fallow. In this case the previous crop is disked in, a preplant herbicide is applied, and the land is disked as needed in the summer. Yield following fallow may be lower than for crops following crops. Salts may come to the surface of the soil from not being irrigated. Also, beneficial organisms in the soil may decline without a crop or moisture. (2) Safflower may be grown as a cover crop. (3) A green manure or wheat may be grown for green chop. (4) An old alfalfa field that was coming out of alfalfa may be left to meet the ACR requirements. The ACR ground is left fallow in this study.

REVENUE

The almond enterprise has revenue only from the sale of almonds. The cotton enterprise has revenue from the sale of lint and seed. The cotton enterprise also receives revenue from a producer option payment and a deficiency payment due to participation in the government program.

LABOR

Basic hourly wages for workers are $8.00 and $5.00 per hour for machine operators and field workers (irrigator), respectively. Adding 34% for SDI, FICA, insurance, and other benefits increases the labor rates to $10.72 per hour for machine labor and $6.70 per hour for nonmachine labor. These rates are assumed to be constant over the year so that a worker paid in February and in June both receive the same hourly salary.

GENERAL OPERATING COSTS

The costs for fertilizer and pesticides are for materials only, the cost of application is included in the calculations for custom operations, labor, and machines. The assessment on almonds is a marketing fee collected by the Almond Board of California. The assessment is $0.0225 per meat pound and is used for advertising of almonds. The cost of $45 is based on expected production of 2,000 pounds. There are several assessments on cotton calculated on a per bale basis. These assessments were computed in a fashion similar to almonds for the purposes of cost estimation.

CASH OVERHEAD

Cash overhead consists of various cash expenses paid out during the year that are assigned to the whole farm and not to a particular enterprise. These costs include property taxes, office expense, liability and property insurance, sanitation services, and equipment repairs.

Property Taxes

Counties charge a base property tax rate of 1% on the assessed value of the property. In some counties special assessment districts exist and charge additional taxes on property including equipment, buildings, and improvements. For this study, county taxes are calculated as 1% of the average value of the property. Average value equals new cost plus salvage value divided by 2 on a per acre basis. For owned land, estimated property taxes are assessed at 1% of the value of the property. For rented land, no property tax assessment is made in the estimates because the rental rate implicitly includes property taxes.

Interest Rates

Interest on operating capital and all other with-in period calculations is charged on a nominal basis. It is calculated monthly until harvest at a nominal rate of 10% per year. All expendable inputs are assumed to be purchased for cash off the farm and so all interest is explicit interest. The real interest rate of 4% used to calculate capital recovery costs is the USDA-ERS's ten-year average of California's agricultural sector long-run rate of return to production assets from current income adjusted for inflation. It is used to reflect the long-term real rate of return to these specialized resources that can only be used effectively in the agricultural sector. In other words, the next best alternative use for these resources is in another agricultural enterprise. With a nominal rate of 10% and a real rate of 4%, the implicit inflation rate is 5.769% $\left(\frac{1.1}{1.04} \& 1\right)$.

Insurance

Insurance for farm investments varies depending on the assets included and the amount of coverage. Property insurance provides coverage for property loss and is charged at $5 per $1,000 (.5%) of assets on the average value of the assets over their useful life. Liability insurance covers accidents on the farm and costs $850 for the entire farm.

Office Expense

Office and business expenses are estimated at $30 per acre. These expenses include office supplies, telephones, bookkeeping, accounting, legal fees, road maintenance, etc.

NONCASH OVERHEAD

Noncash overhead is the capital recovery cost for equipment, buildings, irrigation system, orchard trees, land, and miscellaneous tools. Although farm equipment might be purchased new or used, this study collected data on current purchase price for new equipment. These prices were obtained from local dealers and are a mixture of list and purchase prices. This new equipment price is adjusted to 60% of its reported value to indicate a mix of new and used equipment.

The value of the trees as an asset is the net total operating costs for the preproductive years of the orchard. It includes land preparation, planting, and operating costs up until the year prior to harvest. For all 95 acres of almonds this cost is estimated to be $171,190 giving a per acre cost of $1,802 as compared to a per acre cost of $4,494.669 for the almond orchard discussed in Chapter 10 and Appendix 10A.

Capital Recovery Costs

Capital recovery cost is an estimate of the annual depreciation and interest costs for a capital investment. It is the amount of money required each year to recover the difference between the purchase price and salvage value (unrecovered capital). Put another way, it is equivalent to the annual payment on a loan for the investment with the down payment equal to the discounted salvage value. This is a more complex method of calculating ownership costs than straight-line depreciation and opportunity costs, but more accurately represents the annual costs of ownership because it appropriately takes the time value of money into account. The calculation for the annual capital recovery costs uses equation 6.8 as follows:

$$CSC = (Purchase\ Price - Salvage\ Value)\left(\frac{r}{1-(1+r)^{-n}}\right) + (Salvage\ Value)(r)$$

$$= (Purchase\ Price - Salvage\ Value) \times \begin{pmatrix} Capital \\ Recovery \\ Factor \end{pmatrix} + (Salvage\ Value) \times (Interest\ Rate)$$

Because the purchase and salvage prices used are beginning of year values, this cost is adjusted to the end of the year using the implicit inflation rate of 5.769%.

Salvage Value

Salvage value is an estimate of the remaining market value of an investment at the end of its useful life. It is calculated differently for different investments. For farm machinery (e.g., tractors and implements) the remaining value is a percentage of the new cost of the investment. Salvage value is calculated as:

$$New\ Purchase\ Price \times \%\ Remaining\ Value$$

Many of the machines used on these operations are not covered by the Cross and Perry or the ASAE remaining value equations. Based on discussions with dealers the % Remaining Value is assumed to be 10% for almost all farm machinery. This is assumed to represent a real salvage value with the same purchasing power as the purchase price. Salvage value for other investments including irrigation systems, buildings, trees, and miscellaneous equipment is zero. The salvage value for land is equal to the purchase price because land does not typically depreciate.

Capital Recovery Factor

The capital recovery factor is the amortization factor or annual payment whose present value at compound interest is 1. It is the function of the interest rate and years of life of the equipment. Its reciprocal is represented by US_0, which for the nominal case is given by equation 2B.8. For real interest rate r and payment length n it is given by

$$US_0(r,n) = \frac{\left(1 - (1+r)^{-n}\right)}{r}.$$

Capital recovery for the establishment of the almonds is computed using equation 6.8 as follows. The purchase price (preproductive cost) is $171,190. The salvage value is $0.00. The capital service cost or capital recovery annuity is

$$\begin{aligned} CSC &= \frac{(PP - SV)r}{1 - (1+r)^{-n}} + SV(r) \\ &= \frac{(171{,}190 - 0)(0.04)}{1 - (1.04)^{-19}} + (0)(0.4) \\ &= \frac{6{,}847.60}{0.525357} \\ &= 13{,}034.17\,. \end{aligned}$$

Dividing this by 95 acres we obtain a real capital recovery cost per acre for the establishment cost of almonds of $137.20. The capital recovery cost of machinery for almonds is $80.92. The capital recovery for buildings, irrigation equipment, fuel tanks, pruning equipment and shop tools is $28.88 per acre. This gives a total per acre real cost of $247.00 (137.20+80.92+28.88). Adjusted to the end of the year this is $261.25 [(247)(1.05769)]. Capital recovery for cotton is computed in a similar manner.

EQUIPMENT CASH COSTS

Equipment costs are composed of three parts: noncash overhead such as capital recovery, cash overhead such as property taxes, and operating costs. Both of the overhead factors have been discussed in previous sections. The operating costs consist of repairs, fuel, and lubrication.

Repair costs are based on the prices collected from dealers. These prices (which are a mixture of list and purchase prices) may be slightly less than the list price but are assumed to be a list prices for purposes of repair estimation. Using these prices, annual hours of use, total hours of life, and repair coefficients formulated by the American Society of Agricultural Engineers (ASAE), repairs are then estimated using equation 5.8. Fuel and lubrication costs are also determined by ASAE equations based on maximum PTO HP (equation 5.19) and type of fuel used. The fuel and repair cost per acre for each operation in the CAR is determined by multiplying the total hourly operating cost for each piece of equipment used for the cultural practice by the number of hours per acre for that operation. Tractor time is 10% higher than implement time (operation time) for a given operation to account for fueling, moving equipment, and setup time. Prices for on-farm delivery of diesel and gasoline are $0.71 and $.98 per gallon, respectively. This operation did not use any electricity.

LAND

Owned land was valued at $5,000 per acre. The farm consists of 100 acres of owned land. There are 95 acres in the almond orchard with another 5 acres of owned land for roads and farmstead. The total cost of owned land is $500,000 [(100)(5,000)]. The cost of land is then $5,263.16 per acre in production (500,000/95). Multiplying by the real interest rate of 4% gives an annual cost per acre of $210.52.

All of the land for cotton production was rented at a rate of $140.00 per acre. Total acres rented was 1,200, of which 500 was planted to cotton, 56 was allocated to cotton ACR, 10 was in roads and turnarounds, and 634 was allocated to other field crops. Five of the 10 acres in roads and turnarounds was allocated to cotton production. The rental cost per planted acre of cotton was calculated by adding the total cost of all land needed for the cotton enterprise and dividing this by the 500 planted acres. This gives [(500+56+5)($140)/500] $157.08 per acre.

GOVERNMENT PROGRAM PARTICIPATION

Government payments from participation in the cotton program are included as the gross value of production for cotton. Payments are received for the payment acres at the rates of $.21 per pound of lint deficiency payment and $.08 per pound of lint producer option payment (POP). The POP payment is based on 1,100 pounds of lint at $0.08 per pound for a total payment of $88.00 per planted acre. The deficiency payment is based on $.21 per pound on 1,100 pounds for a potential payment per planted acre of $233.00. But, the deficiency payment is not applicable to flex acres as explained in the paragraph below.

The ASCS base acreage is 556 acres. The required 10% Acreage Reduction (ACR) equals 56 acres and the required 15% flex acres equals 83 acres. All of the flex acres are planted to cotton. Therefore, there are 500 acres of planted cotton of which 417 are payment acres since flex acres are not eligible for payments. The planted acres equal 90% (100-10) of the base acres and the payment acres equal 75% (100 - 10 - 15) of the base acres. The percentage of planted acres that are also payment acres equals the ratio of the payment acres to the planted acres. It follows that 83.33% (.75/.90) of the planted acres receive payments. This gives a payment per planted acre of $192.50 [(233.00)(83.3333)].

The operations performed to maintain the 10% of cotton base that is in ACR land are included. The cost is spread out over the cotton acreage and included in the CAR estimate. For every nine acres of cotton there is one acre that is in ACR. On a per acre basis, the cost of each acre of cotton includes the costs of maintaining an additional .11 (1/9) acre in ACR.

Table 15.1 A Sample Brief CAR Summary for an Almond Budget Projected Almond				
Production Costs and Returns per Planted Acre San Joaquin Valley, California 1992				
Item	Dollars			
Gross value of production:				
Almonds	$2,000.00			
Operating costs:				
Fertilizer	$59.25			
Pesticides	212.09			
Water	19.2			
Custom operations	483.5			
Fuel, lube, and electricity	21.78			
Repairs	40.24			
Assessments	45		Almonds	
Interest on operating capital	48.12			
Miscellaneous	16.1			
Total operating expenses	$945.28	$945.28		
Overhead costs:				
General farm overhead	$30.00			
Taxes and insurance	106.13			
Interest on land	210.52		Is this 4% of 499.985	
Capital recovery	203.09	192.01	Based on beginning of	
Hired labor	255.77	72.5		
Opportunity cost of unpaid labor				
Interest on nonland capital	72.5		What is this that is nc	
Total overhead costs	$878.01	$866.93	covered in capital reco	
Total costs	$1,823.29	$1,812.21		
Gross value of production less costs	$176.71	$187.75		
Harvest period price (dollars per lbs.)	$1.00			
Yield (pounds per planted acre)	2,000			

Table 15.2 Sample Brief CAR Summary for a Cotton Budget
Projected Cotton Production Costs and Returns per Planted Acre,
San Joaquin Valley, California 1992

Item	Value		
Gross value of production:			
Lint	$627.00		
Seed	108		
Producer option payment	74.8		
Deficiency payment	196.35		
Total Revenue	$1,006.15		
Operating costs:			
Seed	$11.20		
Fertilizer	44.3		
Pesticides	98.28		
Water	87.36	887.36	
Custom operations	197.42		
Fuel, lube, and electricity	22.35		
Repairs	32.21		
Assessments	15.92		
Interest on operating capital	24.22		
Miscellaneous			
Total Operating Costs	$533.26		
Allocated Overhead			
General farm overhead	$30.00		
Taxes and insurance	6.93		
Interest on land			
Opportunity cost of land (rental rate)	155.68		
Capital recovery	92.36	87.32	
Hired labor	91.35		
Opportunity cost of unpaid labor			
Interest on nonland capital	18.48		
Total Allocated Overhead	$394.80	$389.76	$5.04
Total Costs Listed	$928.06	$923.02	$5.04
Value Of Prod. Less Total Costs Listed	$78.09	83.13	($5.04)
Harvest period price			
Lint ($/lb.)	$0.57		
Seed ($/ton)	0.24		
Harvest period yield			
Lint (lb./acre)	1,100		
Seed (tons/acre)			

Schedule 15.1: 1992 Crop Acreage and Production – California Cotton-Almond Farm

Crop	Planted Acres	Harvested Acres	ASCS Base	Payment Acres	Flex Acres	ACR Acres	Production Yield	ASCS Yield	Units	Landlord's Share
Cotton-lint	500	500	556	417	83	56	550,000	1,100	Lbs.	0
Cotton-seed							450		Tons	0
Almonds	95	95					190,000		Lbs.	0

Schedule 15.2: Not applicable.

Schedule 15.3: Not applicable.

Schedule 15.4: 1992 Assumed Labor Hours and Cash Wages – California Cotton–Almond Farm

Labor Category	Compensation		Annual Hours of Work Per Acre	
	Cash Wages	In Kind	Cotton	Almonds
Machine	10.72	0	4.68	10.45
Non-machine	6.70	0	6.14	21.46

Schedule 15.5A: Operating Inputs and Machinery Operations for Almonds – California Cotton–Almond Farm

Month	Machinery Operations					Operating Input			
	Operation	Hrs./A	Machine 1	Machine 2	Machine 3	Item	Units/A	Units	$/Unit
November	Prune	11.00							
November	Stack brush	.70							
November	Buck brush	.12	Tractor 60hp 2wd	Brush rake & loader					
December	Knock mummies					Shake nuts - custom	.50	hr.	60.00
December	Blow & rake	.15				Sweep nuts - custom	.25	hr.	35.00
December	Shred_		Tractor 60hp 2wd	Flail mower - 10 ft.					
December	Stack brush	.70							
December	Buck brush	.12	Tractor 60hp 2wd	Brush rake & loader					
December	Weed control	.12	Tractor 30hp 2wd	Weed sprayer 100gal.		Roundup	.66	pint	5.07
						Surflan	1.00	pint	9.92
						Goal	.34	qt.	21.27
December	Pest control	.20	Tractor 60hp 2wd	Orch. sprayer 500gal.		Dormant oil	2.50	gal.	2.75
						Kocide	4.00	lb.	2.00
						Lorsban	.50	pint	6.48
January	Knock mummies					Shake nuts - custom	.50	hr.	60.00
January	Blow & rake					Sweep nuts - custom	.25	hr.	35.00
January	Shred	.15	Tractor 60hp 2wd	Flail mower - 10 ft.					
January	Stack brush	.70							
January	Buck brush	.12	Tractor 60hp 2wd	Brush rake & loader					
January	Remove a tree	1.00				Backhoe rental	1.00	acre	14.25

Schedule 15.5A (continued)

Month	Machinery Operations					Operating Input			
	Operation	Hrs./A	Machine 1	Machine 2	Machine 3	Item	Units/A	Units	$/Unit
January	Plant Tree, Carton/tank	.30				Almond tree	1	each	3.80
						Tree carton	1	each	.05
						Tank mix	1	tree	.20
January	Burn Prunings	.30							
January	Weed Control	.12	Tractor 30hp 2wd	Weed Sprayer 100gal		Roundup	.67	pint	5.07
						Surflan	1	pint	9.92
						Goal	.33	qt.	21.27
January	Pest Control	.20	Tractor 60hp 2wd	Orch. Sprayer 500gal		Dormant Oil	2.50	gal.	2.75
						Kocide	3	lb.	2.00
						Lorsban	.50	pint	6.48
February	Weed Control	.12	Tractor 30hp 2wd	Weed Sprayer 100gal		Roundup	.67	pint	5.07
						Surflan	1	pint	9.92
						Goal	.33	qt.	21.27
February	Pest Control	.40	Tractor i60hp 2wd	Orch. Sprayer 500gal		Rovral	1	lb.	23.35
February	Pollination					Hive rental	1	hive	30.00
February	Irrigate	.30				Water - district	4	acin	.48
February	Pest Control	.13	Tractor 60hp 2wd	Orch. Sprayer 500gal		Ziram	8	lb.	2.65
						Zinc	5	lb.	1.10
						Boron	4.50	lb.	.79
March	Weed Control	.13	Tractor 30hp 2wd	Weed Sprayer 100gal		Roundup	2	pint	5.07

Schedule 15.5A: Operating Inputs and Machinery Operations for Almonds – California Cotton–Almond Farm (continued)

	Machinery Operations					Operating Input			
Month	Operation	Hrs./A	Machine 1	Machine 2	Machine 3	Item	Units/A	Units	$/Unit
April	Fertilizer & App.	.40	Tractor 30hp 2wd			Sprayer rental	1	acre	5.00
						UN-32	50	lb.	.25
April	Miscellaneous	.30				Miscellaneous	1	acre	2.25
April	Irrigate	.30				Water - district	4	acin	.48
April	Mow Centers	.25	Tractor 60hp 2wd	Flail Mower - 10’					
May	Rodent Control	.06	ATV 4wd	Sprayer		Strychnine	1	each	1.00
May	Irrigate	.30				Water - district	4	acin	.48
May	Mow Centers	.25	Tractor 60hp 2wd	Flail Mower - 10’					
June	Irrigate	.50				Water - district	8	acin	.48
June	Mow Centers	.25	Tractor 60hp 2wd	Flail Mower - 10’					
June	Leaf Analysis	.10				Leaf analysis	1	acre	.50
June	Ant Control	.12	Tractor 60hp 2wd	Weed Sprayer 100gal		Lorsban	.50	pint	6.48
July	Ant Control	.12	Tractor 60hp 2wd	Weed Sprayer 100gal		Lorsban	.50	pint	6.48

Schedule 15.5B: Operating Inputs and Machinery Operations for Cotton – California Cotton–Almond Farm

	Machinery Operations					Operating Input			
Month	Operation	Hrs./A	Machine 1	Machine 2	Machine 3	Item	Units/A	Units	$/Unit
January	Deep rip	.08	Crawler, D8	Ripper 10’		D8 rental	.08	hr.	$44.00
						Delivery	1	hr.	.60
January	Deep rip ACR land	.01	Crawler, D8	Ripper 10’					
January	Primary discing	.14	Crawler, D7	Offset disc 21’		D7 rental	.14	hr.	38.00
						Delivery	1	hr.	.60
January	Primary disc-ACR land	.02	Crawler, D7	Offset disc 21’					
January	Preplant NH3					NH3	122	lb.	.16
						Broadcast, custom	1	app.	4.75
February	Apply herbicide	.12	Tractor 2wd 100hp	Sprayer TM 220gal		Treflan	2	pint	4.13
February	Apply herbicide-ACR	.01	Tractor 2wd 100hp	Sprayer TM 220gal		Treflan	.2	pint	4.13
February	Incorp. herbicide	.10	Tractor 2wd 170hp	Disc, tandem 24’					
February	Incorp. herbicide-ACR	.01	Tractor 2wd 170hp	Disc, tandem 24’					
February	Make beds	.15	Tractor 2wd 170hp	Lister, 6 row					
February	Make ditch	.02	Tractor 2wd 170hp	Ditch opener					
February	Irrigate	1.00				Water	6	acin	2.08
February	Close ditch	.02	Tractor 2wd 170hp	Ditch closer					
April	Plant	.18	Tractor 2wd 100hp	Planter, 6 row		Seed	14	lb.	.80
April	Uncap beds	.15	Tractor 2wd 100hp	Uncapper, 6 row					
April	Cultivate	.25	Tractor 2wd 100hp	Uncapper, 6 row					

Schedule 15.5B (continued)

Month	Machinery Operations					Operating Input			
	Operation	Hrs./A	Machine 1	Machine 2	Machine 3	Item	Units/A	Units	$/Unit
May	Cultivate 2X	.40	Tractor 2wd 100hp	Cultivator, 6 row					
May	Hand weeding					Contractor labor	1	time	25.00
May	Apply miticide					Comite	2	pint	9.00
						Air application	1	app.	5.00
June	Make ditch	.02	Tractor 2wd 170hp	Ditch opener					
June	Irrigate 2X	2.00				Water	18	acin	2.08
June	Close Ditch	.02	Tractor 2wd 170hp	Ditch closer					
June	Cultivate 2X	.50	Tractor 2wd 100hp	Cultivator, 6 row					
	Cultivate 2X-ACR	.05	Tractor 2wd 100hp	Cultivator, 6 row					
June	Insect control					Orthene 90	1.33	lb.	8.35
						Air application	1	app.	5.00
June	Layby cultivate/herbicide					Caporal	4.80	pint	4.13
						Banding, custom	1	acre	6.25
July	Make ditch	.02	Tractor 2wd 170hp	Ditch opener					
July	Irrigate	1.00				Water	9	acin	2.08
July	Apply growth regulator					Pix	1	pint	15.38
						Air application	1	app.	5.00
July	Sidedress fertilizer					11-52-0	177	lb.	.14
						Custom application	1	app.	8.50

Schedule 15.5B (continued)

Month	Machinery Operations					Operating Input			
	Operation	Hrs./A	Machine 1	Machine 2	Machine 3	Item	Units/A	Units	$/Unit
August	Irrigate	1.00				Water	9	acin	2.08
September	Close ditch	.02	Tractor 2wd 170hp	Ditch closer					
October	Defoliate cotton					Pix	1	pint	15.38
						Air application	1	app.	5.00
November	Harvest	.67	Harvester, 2 row						
November	Build module	.43	Tractor 2wd 100hp	Module builder		Tarps, module	.19	each	50.00
November	Cut stalks	.12	Tractor 2wd 170hp	Flail chopper					
November	Cross disc	.19	Tractor 2wd 170hp	Disc, tandem 24’					
November	Ginning					Gin - lint	2.15	bale	50.00
November	Pickup use	.27	Pickup, 3/4 ton						

Schedule 15.6: Buildings and Improvements 1/1/92 – California Cotton–Almond Farm

Item	Year of Purchase	Replacement Purchase Cost	Market Value	Useful Life Remaining	Annual Repairs	Percent Allocation by Enterprise		
						Cotton	Other	Almonds
Buildings	92	$65,000	$65,000	25	$100	38	54	8
Orchard Trees	92	171,190	171,190	19	0	0	0	100
Flood Irrigation System	92	170,772	170,772	20	100	83	0	17
Fuel Tanks & Pumps	92	8,100	8,100	20	125	38	54	8
Land (95 acres in production)	92	500,000	500,000	--	--	--	--	100
Pruning Equipment	92	1,200	1,200	10	25	0	0	100
Shop Tools	92	11,000	11,000	15	100	38	54	8

Schedule 15.7: Machinery and Equipment Inventory and Use – California Cotton–Almond Farm

Description	Size	Useful Life Remaining	Year of Purchase	Replacement Purchase Cost	Salvage Value	Hours of Use by Enterprise		
						Cotton	Other	Almonds
Cultivator #1	6 row	5	92	$ 3,750	$ 375	250	0	
Cultivator #2	6 row	5	92	3,750	375	250	0	
Cultivator #3	6 row	5	92	3,750	375	73	156	
Disc, tandem	24’	15	92	20,000	2,000	152	23	
Ditch closer		15	92	5,629	563	30	136	
Ditch opener		15	92	8,950	895	30	136	
Flail chopper		5	92	9,865	987	50	200	
Harvester #1	2 row	5	92	117,700	11,770	89	0	
Harvester #2	2 row	5	92	117,700	11,770	90	0	
Lister	6 row	10	92	3,750	375	179	0	
Module builder		5	92	21,000	2,100	73	176	
Offset disc	21’	5	92	15,000	1,500	242	0	
Pickup	3/4 ton	5	92	16,000	1,600	80	0	
Planter #1	6 row	5	92	15,000	1,500	133	133	
Planter #2	6 row	5	92	15,000	1,500	44	196	
Ripper	10’	5	92	12,500	1,250	44	196	
Spray TM	220 gal	5	92	8,100	810	72	178	
Tractor 2wd #1	100hp	10	92	40,000	4,000	1,094	106	
Tractor 2wd #2	100hp	10	92	40,000	4,000	48	1,152	
Tractor 2wd	170hp	10	92	$60,000	$6,000	370	830	
Uncapper	6 row	10	92	2,300	230	73	0	
Tractor, 2wd	30hp	15	92	18,100	1,810			128
Tractor, 2wd	60hp	15	92	26,400	2,640			458
ATV & Sprayer, 4wd		10	92	6,955	696			10
Brush Rake & Loader		25	92	6,000	600			38
Flail Mower	10’	10	92	5,000	500			195
Orch. Sprayer	500 gal.	8	92	16,050	1,605			152
Pickup Truck	½ ton	7	92	16,500	1,650			285
Weed Sprayer	100 gal	10	92	3,424	342			72

Schedule 15.8: Annual Business Overhead Costs – California Cotton–Almond Farm

Description	Total Cost	Percent Allocation by Enterprise		
		Cotton	Other	Almonds
Office Expense	$38,550	38	54	8
Property taxes - nonland	2,136	25	35	40
Property taxes - land	5,000			100
Insurance	3,568	25	35	40
Investment repair	450	38	54	8

Schedule 15.9: Rates and Prices – California Cotton–Almond Farm

Description	Rate	Units
Nominal interest rate	10%	annual
Real interest rate	4%	annual
Insurance	$5.00	per $1,000 assets
Property tax	$1.00	per $100 property
Diesel fuel	$.71	gallon
Gasoline	$.98	gallon

GLOSSARY

Accumulated (cumulated) repair costs *Total machinery repair costs incurred since the machine was purchased (new).*

Allocated overhead *All enterprise costs except those associated with expendable inputs.*

Annuity *A sequence of equal payments, made at equal intervals of time. In cost and return (CAR) estimation one often finds the annuity that has the same present value as a time varying stream of income. For example, the purchase of an asset at the beginning of period 1 with real value V_0, with sale at the end of period n for real payment V_n has a specific present value for a given real interest rate (r). One is often interested in the annuity (equal payments in each time period over n periods) that has the same present value. The present value of this income stream is* $V_0 - \frac{V_n}{(1+r)^n}$. *The real annuity ($a^r$) with the same present value is*

$$a^{real} = \frac{\left(V_0 - \frac{V_n}{(1+r)^n}\right)}{\left(\frac{1 - (1+r)^{-n}}{r}\right)} = \frac{\left(V_0 - \frac{V_n}{(1+r)^n}\right)}{US_0(r,n)}.$$

If all values are in nominal terms then a nominal interest rate (i) is used for discounting and the annuity is also in nominal terms, i.e.,

$$a^{nom} = \frac{\left(V_0^{nom} - \frac{V_n^{nom}}{(1+i)^n}\right)}{\left(\frac{1 - (1+i)^{-n}}{i}\right)}.$$

AUM *Abbreviation for animal unit month and indicates the carrying capacity (forage yield) of a pasture or range for various classes of animals.*

Bulk commodities *Items produced for sale or farm use as inputs to other production activities including those used in off-farm industrial uses. These items almost always require some level of intermediate processing before consumed.*

Capital *Stock that is not used up during a single production period, provides services over time, and retains a unique identity. Examples include machinery, buildings, equipment, land, breeding livestock, stocks of natural resources, production rights, and human capital.*

Capital services *Flow of productive services that can be obtained from a given capital stock during a production period. These services arise from a specific item of capital rather than from a production process. It is usually possible to separate the right to use services from ownership of the capital good.*

Capital service cost *The cost of providing the services of a capital asset for a specific time period (usually one production period). This cost is usually made up of the following items:*

Opportunity cost of holding the asset

% service capacity reduction cost

*% change in the price of the capital asset*s remaining service capacity*

% service enhancement cost

% maintenance cost

% other time costs.

Carryover *The amount of an input, such as fertilizer, that is applied in one season but still provides a residual service in the following period.*

Commodities or products *Specific items produced by production activities and marketed by marketing activities.*

Commodity quality *The differentiated characteristics of a commodity that determine when, where, how and at what price it can be sold, often measured by grades.*

Composite CAR (farm) *A simple or weighted average of enterprise CARs for some period for some group of individual or representative farms.*

Consumer commodities *Items that are produced for direct consumer use. Production activities often include some on-farm processing, marketing, or packaging.*

Contract labor *Work performed on a farm or ranch, such as fruit or vegetable picking, when the provider of the service (crew leader, contractor, etc.) is paid for the use of materials, equipment, or labor as agreed to informally or as specified in a contract.*

Custom operation *The joint hiring of machinery, labor, and/or materials to perform some field operation or activity.*

Custom rates *Charges or expenses incurred by a farmer for a custom operation.*

Custom work *Agricultural work performed by laborers and machines hired as a unit.*

Database *A comprehensive set of data together with sufficient documentation to make it accessible, preferably by computer.*

Data file *The complete collection of variables, data values, etc. which are needed to meaningfully use the data.*

Discount rate or rate of interest *The market determined rate of time preference for the numeraire commodity in the economy (money).*

Discounting *The process of adjusting cost or return streams to a common point in time using market or individual rates of discount. This process is also called present or future value analysis.*

Durable or durable asset *A term often used to describe physical capital such as machinery and equipment that provides service for more than one period. The term durable implies long-lived or not temporary.*

Economic depreciation *The change in the value of an asset over a single period* (V_0 - V_1)*. It can occur because of a* ***reduction in the service potential*** *of the asset or due to* ***changes in market prices****.*

Editing *The process of changing one or more coefficients used in a specific CAR budget.*

Engineering approach/equations *Mathematical relationships developed by agricultural engineers to estimate typical costs for a given machine. These are typically reported in annual editions of the ASAE Standards.*

Enterprise *(see production enterprise)*

Enterprise allocation *A method, either objective or subjective, of allocating whole-farm expenses to each enterprise on a farm.*

Expected price *The price anticipated or forecasted for some specified future period.*

Expected yield *A forecast of yields for planning purposes. It can be based statistically or subjectively on historic yields, experimental data, or subjective factors.*

Expendable factors of production *Raw materials, or produced factors that are completely used up or consumed during a single production period. Common examples of these factors that lose their identity with a single use are seed, fuel, lubrication, some pesticides and fertilizer, feed, and feeder animals.*

Factor of production (input) *Goods and services that are employed in the production process. Some factors are purchased; others are produced within the operation.*

Farm labor *All hired, contract, exchange, and unpaid family labor used in agricultural production. Farm labor is defined here to encompass what is sometimes distinguished as traditional labor, management and other overhead time, and also includes labor acquired through farm labor contractors and all semiskilled services used in farming, such as mechanics for machinery and building repair, and bookkeepers.*

Field efficiency *The effective accomplishment of a machine, expressed in percent, as compared to the theoretical maximum area covered in a specific period of time at a specific field speed.*

Field operations *The listing of all tractor and machinery operations performed on a given acre or field.*

Field performance/capacity *The efficiency of a machine expressed in terms of acres per hour, tons per acre, or some other units.*

Fisher equation *An equation that relates the real interest rate (r), the rate of inflation (π), and the nominal interest rate as follows* $(1 + \pi)(1 + r) = (1 + i)$.

Forecasting *Projecting CARs for some future period based on expected input-output coefficients and a set of prices. The procedures recommended by the Task Force are primarily used for planning or analysis of expected response. The resulting CARs can therefore be defined as forecasts of expected CARs based on documented input-output relationships and prices.*

Format *A set of directions that describes a field or location and the contents of that field to help the computer to read and write data values.*

Government payments *Direct cash or in-kind payments to farms for complying with specific government requirements. In the U.S., government farm program payments may require farmers to meet certain conditions, including setting aside (not planting) some acreage, before direct payments are made. Such government payments are usually related to specific crops and commodities. Conditions for payment change each year.*

Harvested yield *That portion of the yield that is collected for possible use. Harvesting charges are often based on harvested yield.*

Historic price *The price realized in some specified historic period.*

Historic yield *The output per technical production unit as observed from historic data.*

Historical CAR estimates *A summary of enterprise CARs for some historical period such as the past calendar year, crop year, or production cycle.*

Individual farm *Either a specific farm currently or previously in operation or a representative farm that has a set of resources, production practices, objectives, and enterprises similar to some class of actual farms.*

Inflation rate (B) *The rate at which the general level of prices increases over time.*

Intermediate products (inputs) *Bulk commodities that are consumed by another production activity on-farm without directly entering the marketing system.*

Joint products *Two or more distinct commodities produced by a single enterprise or technical unit. Such products may be produced in fixed, or in variable, proportions to one another.*

Laborers *The number or inventory of persons at a point in time. Workers are generally heterogenous because of differences in productive skills, location, and availability for work. Labor is services (person-years per year) and includes all human time using activities, including what is sometimes labeled separately as labor and management.*

Machinery set *A combination of machines found on a (representative) farm.*

Machinery operating costs *Expenses farmers incur when they operate crop and livestock machines (excluding overhead costs) including costs for fuel, repairs, lubrication, operating interest, and labor.*

Maintenance costs *The expenses required to maintain the service potential of a capital asset at a reasonable level and to extract services for a single time period. Activities associated with these costs are not usually viewed as enhancing the service capacity of the capital asset in any significant way when determining its end-of-period value.*

Marketable yield *That portion of the yield which is marketable. The salable portion of the product is often diminished from the harvested yield.*

Marketing activity *The activity of selling the product or products. Marketing begins when the decision maker initiates activities directed at selling the commodity. Activities after the point the commodity reaches the final marketing form while still under the ownership of the farmer are marketing activities.*

Modelbase *The set of equations and the specified calculation procedures that are used to manipulate/use a database, for example, a CAR modelbase.*

Multiyear enterprise *An enterprise with more than one annual production period.*

Nominal rate of interest (r) or discount *The market rate of time preference for the numeraire commodity (money) in terms of current prices and incomes. This rate is not adjusted for the expected (or realized) rate of inflation.*

Nondurable *(see expendable factors of production)*

Operating costs *The costs of all expendable inputs used in a particular enterprise.*

Opportunity cost *The value of any good or service in its next best alternative use. For example, the opportunity cost of the service of an input used in the production of any particular commodity is the maximum amount that the input would produce of any other commodity. Opportunity costs are usually measured in monetary terms so that the opportunity cost of any good or service is the maximum amount the good or service could receive elsewhere for use as a production input or for final consumption. The opportunity cost of financial capital is usually measured by the discount rate.*

Output or production *The quantity of a commodity produced by a farm enterprise expressed in traditional output units. Production can refer to output from a single production unit, or to the aggregate of production units for a farm or a region.*

Output unit *(unit) The standardized physical unit used to measure output. These can be English, metric, or other traditional units.*

Preproductive period *(for a multiyear crop enterprise) The period that begins with the first expense associated with establishing the crop enterprise and ends in the crop year just before the crop yields a substantial percent of its expected mature yield (usually 70-80%). A similar definition holds for livestock enterprises.*

Price *The per unit value (explicit or implicit) received from the sale or transfer of commodities.*

Price change costs *Costs associated with changes in the market value of a capital good (with a fixed service flow) during a single production period that occur because of general inflation or deflation or changes in market conditions related to that specific capital item.*

Production activity *The activity of an enterprise that relates to producing products. Production activity begins with the physical and financial decision to produce. It ends when the commodity reaches the final marketing form while still under the ownership of the farmer whether this final form is reached on the farm or off the farm.*

Production enterprise (enterprise) *Any coherent portion of the general input-output structure of the farm business that can be separated and analyzed as a distinct entity. Such an entity uses inputs and incurs costs while producing products or services.*

Production system or method *A description of a given production process including the factors of production or inputs (including quantity and timing) and the set of outputs produced.*

Profits (to the firm or enterprise) *The revenues from production minus all the market-determined costs of factors and the opportunity cost of the operator's time and any other unaccounted for resources.*

Projected CAR estimates *Forecasts of enterprise CARs for some future period such as the coming calendar year or crop year and are based on information available at a certain point in time.*

Real rate of interest (r) or discount *The market rate of time preference for the numeraire commodity (money) adjusted for changes in purchasing power so that it reflects time preferences over goods in different time periods.*

Receipts *The sum of the cash payments a farmer receives for the sale of commodities that results from a production activity.*

Remaining value (of an asset) *The ratio of the current market price (conceivably at the end of the costing period) to the initial purchase price of the asset. This is often expressed as a percentage.*

Residual returns (to a given factor of production) *The revenues from production minus the opportunity cost of the operator's time and the market-determined costs of all but that factor of production. With all other factors accounted for, any residual returns are said to accrue to this factor.*

Revenue (Returns) *The total value in monetary terms received from a production activity. This value may be derived from product sales, government payments, estimated cash equivalent value of on-farm use of the commodities, or other sources. Revenue should be directly associated with the production activity.*

Rights to produce *Pertain to incidents of ownership of resources used in production, the impact of regulations governing the use of those resources, access to markets for the commodities produced, and access to enhanced prices or other incentives associated with market access. These rights generally involve payment of rent, royalties, increased production costs, or foregone production in exchange for benefits of enhanced production or markets.*

Risk premium *The difference between the rate of return on a given investment compared to some base investment, usually a risk-free or low-risk bond.*

Salvage value (SV) *The market value of an asset at the end of the costing period.*

Service enhancement costs *The direct costs of increasing the service capacity of a capital asset. They are the costs of expendables and other capital services that are used to alter the productive capacity of the asset. Because these costs allow for the provision of services for more than the current time period, they are normally treated as an investment in a capital asset and not as a period expense when the asset is not sold at the end of the period but is held for future use.*

Service reduction due to time *The decline in the original service capacity of a capital asset that occurs only as a result of the passage of time.*

Service reduction due to use *The decline in the service capacity of a capital asset due to operating, as opposed to not operating. These implicit costs occur because the use of the factor alters its future service potential.*

Software *A program or collection of programs (package) designed for a specific purpose. For example, EXCEL is a spreadsheet software package. Data created by software packages generally hold compressed data and formatting codes that control how they will be displayed on a screen or printed.*

Technical production unit *The standard unit of production activity which produces revenue in a CAR estimate. Two general categories, per unit of land (acre or hectare) or per head of livestock, are commonly used.*

Timeliness costs *Additional expenses associated with excess machinery capacity that is maintained on a farm for purposes of insuring that a particular field operation is performed in a timely manner.*

Transaction costs *Costs incurred to either transform or move a product (physically or in ownership).*

Unpaid farm labor *Work done on a farm or ranch in conjunction with the production of agricultural products where there is no payment for services.*

$US_0(i,n)$ *A uniform series of n payment discounted with interest rate i. The formula for the series is*

$$US_0(i,n) = \sum_{t=1}^{n} \frac{1}{(1+i)^t} = \frac{1 - (1+i)^{-n}}{i}.$$

A uniform series with real interest rate r is denoted $US_0(r,n)$.

Updating *The process of changing the data used in making the CAR estimate. As new data becomes available, users will want to replace the obsolete data. "Updating", as used in this report, refers to the data rather than the calculation procedures and specified input-output relationships.*

V_0 *The value of a cost and/or return stream discounted to the end of period 0 (equivalent to the beginning of period 1). This value can be in real or nominal terms depending on the situation and assumptions made.*

V_n *The value of a cost and/or return stream discounted to the end of period n (equivalent to the beginning of period n+1). This value can be in real or nominal terms depending on the situation and assumptions made.*

Verification *The process of confirming that the data used in the calculations was, in fact, the data the user intended to use.*

Yield *The quantity of commodity per technical production unit produced by a production activity or enterprise for either crops or livestock.*

Yield basis *Refers to whether the yield is historical or potential (forecast); and if historical, over what time frame and region.*

Members of the National Task Force on Commodity Costs and Returns Measurement Methods

Dr. Mary Ahearn
Subcommittee on Labor and Management

USDA ERS RED
Room 4076
1800 M St, NW
Washington, DC 20036-5831
P: 202-694-5600
F: 202-694-5756
E: mahearn@econ.ag.gov

Dr. Eldon Ball
Subcommittee on Durables

USDA ERS RED
Room 4086
1800 M St, NW
Washington, DC 20036-5831
P: 202-694-5601
F: 202-694-5756
E: eball@econ.ag.gov

Dr. Peter Barry
Subcommittee on Land

Department of Ag & Consmr Economics
University of Illinois
326 Mumford Hall
1301 Gregory Drive
Urbana, IL 61801
P: 217-333-1827
F: 217-333-2312
E: p-barry1@uiuc.edu

Dr. Verel Benson
Subcommittee on Data Verification, Editing, Updating, and Sharing

Blackland Research Center
Texas Agricultural Experiment Station
808 E. Blackland Rd
Temple TX 76501
P: 254-770-6630
F: 254-770-6561
E: benson@brcsun0.tamu.edu

Dr. Boris Bravo-Ureta
Subcommittee on Data Sources and Statistical Issues

DARE U-21
University of Connecticut
1376 Storrs Road
Storrs, CT 06269-4021
P: 203-486-1923
F: 203-486-1932
E: bravou@uconnvm.uconn.edu

Dr. Oscar Burt (retired)
Subcommittee on Durables

Department of Agricultural Economics
University of Nebraska
218 Filley Hall
Lincoln, NE 68583
P: 402-472-9410
F: 402-472-3460
E: agec122@unlvm.unl.edu

Dr. George Casler (retired)
Chair, Subcommittee on Report Structure and Content

Department of Economics
Cornell University
Warren Hall
Ithaca, NY 14853-7801
P: 607-255-5445
F: 607-255-6696
E: glc4@cornell.edu

Dr. M. Rafiq Chaudhry
Subcommittee on Labor and Management

International Cotton Advisory Committee
1629 K Street, Suite 702
Washington, DC 20006
P: 202-463-6660
F: 202-463-6950
E: rafiq@icac.org

Dr. Robert E. Coats
Subcommittee on Establishment Costs of Multiyear Enterprises

University of Arkansas
Cooperative Extension Service
PO Box 391
Little Rock, AR 72203
P: 501-671-2195
F: 501-671-2272
E: rcoats@uaex.edu

Dr. Tim Cross
Chair, Subcommittee on Establishment Costs of Multiyear Enterprises

Department of Agricultural Economics
University of Tennessee
PO Box 1071
Knoxville, TN 37901-1071
P: 423-974-7306
F: 423-974-7448
E: tlcross@utk.edu

Dr. Brian Davey (retired)
Chair, Subcommittee on International Comparisons

Ag Canada
98 Quinterra Court
Ottawa, ON
Canada K1V 1K9
P: 613-737-0595 (H)

Dr. Pritam S. Dhillon
Subcommittee on Labor and Management

Agricultural Economics and Marketing
Rutgers, The State University of New Jersey
55 Dudley Road
New Brunswick, NJ 08901-8520
P: 732-932-9156 ext. 19
F: 732-932-8887
E: dhillon@aesop.rutgers.edu

Dr. Robert Dismukes
Subcommittee on Report Structure and Content

USDA ERS MTED
Room 5216
1800 M St, NW
Washington, DC 20036-5831
P: 202-694-5294
F: 202-694-5823
E: dismukes@econ.ag.gov

Dr. Phillip Eberle
Subcommittee on Land

Department of Agribusiness Economics
MC 4410
Southern Illinois University
Carbondale, IL 62901-4410
P: 618-453-1715
F: 618-453-1708
E: eberlep@siu.edu

Dr. Vern Eidman
Coordinator

Department of Applied Economics
316 COB
1994 Buford Avenue
University of Minnesota
St. Paul, MN 55108-6040
P: 612-625-0231
F: 612-625-2729
E: veidman@dept.agecon.umn.edu

Mr. Michael Erker
Subcommittee on Seed, Fertilizer, Chemicals, Feed, Vet and Med, Purchased Livestock

Smith, Bucklin and Associates
540 Maryville Centre Drive Suite LL5
St. Louis MO 63141
P: 314-579-1581
F: 314-579-1599

Dr. Stephen Ford
Subcommittee on Establishment Costs of Multiyear Enterprises

Dept of Ag Econ and Rural Soc
Penn State University
201 Armsby Hall
University Park, PA 16802-5601
P: 814-863-3278
F: 814-865-3746
E: ford@po.aers.psu.edu

Dr. Conrado Gempesaw
Subcommittee on Data Verification, Editing, Updating, and Sharing

Food and Resource Economics
233 Townsend Hall
University of Delaware
Newark, DE 19717-1303
P: 302-831-1315
F: 302-831-3651
E: gempesaw@udel.edu

Dr. Dargan Glaze
Subcommittee on Data Verification, Editing, Updating, and Sharing

Office of Civil Rights
U.S. Department of Agriculture
Room 212 Cotton Annex Mezzanine
300 12th Street, SW
Washington, DC 20250
P: 202-720-6613
F: 202-590-5686
E: Dargan.Glaze@usda.gov

Dr. Cole Gustafson
Chair, Committee on Overhead Costs

Department of Agricultural Economics
North Dakota State University
Fargo, ND 58105-5636
P: 701-231-7096
F: 701-231-7400
E: cgustafs@ndsuext.nodak.edu

Dr. Arne Hallam
Steering Committee

Department of Economics
Iowa State University
269 Heady Hall
Ames, IA 50011-1070
P: 515-294-5861
F: 515-294-0221
E: ahallam@iastate.edu

Dr. David Harrington
Subcommittee on Receipts and Government Program Participation

USDA ERS
Room 4115
1800 M St, NW
Washington, DC 20036-5831
P: 202-694-5571
F: 202-694-5758
E: davidh@econ.ag.gov

Dr. Steve Harsh
Chair, Subcommittee on Data Verification, Editing, Updating, and Sharing

Department of Agricultural Economics
Michigan State University
307 Ag Hall
East Lansing, MI 48824-1039
P: 517-353-4518
F: 517-432-1800
E: harsh@pilot.msu.edu

Dr. Art Heagler (deceased)

Louisiana State University

Dr. Glenn Helmers
Chair, Subcommittee on Durables

Department of Agricultural Economics
University of Nebraska
205 Filley Hall
Lincoln, NE 68583-0922
P: 402-472-1788
F: 402-472-3460
E: agec002@unlvm.unl.edu

Dr. Ralph Hepp
Subcommittee on Fuel, Lube, Repairs, Custom Rates, Commodity Specific Costs, and Miscellaneous

Department of Agricultural Economics
Michigan State University
39 Ag Hall
East Lansing, MI 48824-1039
P: 517-353-7185
F: 517-432-1800
E: hepp@pilot.msu.edu

Dr. Terry Hickenbotham
Subcommittee on International Comparisons

USDA FSA-EPAS Stop 0508
1400 Independence Avenue SW
Washington, DC 20250-0508
P: 202-690-0733
F: 202-690-0733
E: Terry.Hickenbotham@usda.gov

Dr. Herb Hinman
Subcommittee on Establishment Costs of Multiyear Enterprises

Department of Agricultural Economics
Washington State University
203G Hulbert Hall
Pullman, WA 99164-6210
P: 509-335-2855
F: 509-335-1173
E: hinman@wsu.edu

Dr. Robert Hornbaker
Subcommittee on Durables

University of Illinois
305 Mumford Hall
1301 W Gregory Drive
Urbana, IL 61801
P: 217-333-5508
F: 217-333-5538

Dr. Carol House
Chair, Subcommittee on Data Sources and Statistical Issues

Survey Management Division
USDA/National Agricultural Statistics Service
1400 Independence Avenue, SW
Room 4801-S
Washington, DC 20250-2000
P: 202-720-4557
F: 202-720-8738
E: chouse@nass.usda.gov

Dr. Donald Huffman (deceased)
Subcommittee on Land

Louisiana State University

Dr. Wallace Huffman
Chair, Subcommittee on Labor and Management

Department of Economics
Iowa State University
478 Heady Hall
Ames, IA 50011-1070
P: 515-294-6359
F: 515-294-0221
E: whuffman@iastate.edu

Dr. Raleigh Jobes (retired)
Subcommittee on Joint Business Costs and Rights to Produce

Department of Agricultural Economics
Oklahoma State University
Room 511 Ag Hall
Stillwater, OK 74078
P: 405-744-9837
F: 405-744-8210

Dr. James D. Johnson
Subcommittee on Joint Business Costs and Rights to Produce

USDA ERS RED
Room 4117
1800 M St, NW
Washington, DC 20036-5831
P: 202-694-5570
F: 202-694-5758
E: jimjohn@econ.ag.gov

Dr. H. Douglas Jose
Subcommittee on Data Verification, Editing, Updating, and Sharing

Department of Agricultural Economics
University of Nebraska-Lincoln
304 Filley Hall
Lincoln, NE 68583-0922
P: 402-472-1749
F: 402-472-0776
E: agec089@unlvm.unl.edu

Dr. Richard Just
Subcommittee on Data Sources and Statistical Issues

Dept. of Agricultural and Resource Economics
University of Maryland
2200 Symons Hall
College Park, MD 20742-5535
P: 301-405-1289
F: 301-314-9879
E: rjust@arec.umd.edu

Dr. Darrel Kletke
Chair, Subcommittee on Fuel, Lube, Repairs, Custom Rates, Commodity Specific Costs and Miscellaneous

Department of Agricultural Economics
Oklahoma State University
Ag Hall
Stillwater OK 70408
P: 405-744-6170
F: 405-744-8210
E: dkletke@okway.okstate.edu

Dr. Karen Klonsky
Steering Committee

Dept. of Agricultural and Resource Economics
University of California, Davis
1 Shields Avenue
Davis, CA 95616
P: 530-752-3563
F: 530-752-5614
E: klonsky@primal.ucdavis.edu

Dr. Chuck Lambert
Subcommittee on Durables

National Cattlemen's Beef Association
Suite 300
1301 Pennsylvania Avenue NW
Washington, DC 20004
P: 202-347-0228
F: 202-638-0607
E: cl@beef.org

Dr. Mark Lange
Subcommittee on Data Sources and Statistical Issues

National Cotton Council
PO Box 12285
Memphis TN 38112
P: 901-274-9030
F: 901-725-0510
E: mlange@cotton.org

Dr. Larry Langemeier
Subcommittee on Report Structure and Content

Department of Agricultural Economics
Kansas State University
304 Waters Hall
Manhattan, KS 66506-4026
P: 913-532-1516
F: 913-532-6925
E: llange@loki.agecon.ksu.edu

Dr. Jim Libbin
Subcommittee on Seed, Fertilizer, Chemicals, Feed, Vet and Med, Purchased Livestock

Department of Agricultural Economics
New Mexico State University
Box 30003, MSC 3169
Las Cruces, NM 88003-8003
P: 505-646-2915
F: 505-646-3808
E: jlibbin@nmsu.edu

Dr. Lawrence Lippke
Chair, Subcommittee on Joint Business Costs and Rights to Produce

Texas Agricultural Extension Service
Texas A&M University
College Station, TX 77843-2468
P: 409-845-9689
F: 409-845-0829
E: lalippke@tamu.edu

Dr. R. M. A. Loyns
Subcommittee on Receipts and Government Program Participation

Department of Agricultural Economics
University of Manitoba
Winnipeg, MB
R3T 2N2 Canada
P: 204-474-9782
F: 204-269-7774
E: a_lloyns@mb.sympatico.ca.

Mr. Brian McManus
Subcommittee on Seed, Fertilizer, Chemicals, Feed, Vet and Med, Purchased Livestock

Louisiana Public Service Commission
1051 Knoll Haven Drive
Baton Rouge LA 70810
P: 504-752-2378
F: 504-342-4221
E: brianm@lpsc.org

Dr. Tom Miller
Subcommittee on Land

PO Box 15
Moran, WY 83013-0015
P: 303-491-5351

Dr. Mitchell Morehart
Steering Committee

USDA ERS RED
Room 4121
1800 M St, NW
Washington, DC 20036-5831
P: 202-694-5581
F: 202-694-5758
E: morehrt@econ.ag.gov

Mr. Stephen Naught
Subcommittee on Land

National Barley Growers
PO Box 170
Bickleton, WA 99322
P: 509-896-5251 (H)

Dr. Loren L. Parks
Subcommittee on International Comparisons

Pegaso Exports
384 Brookside Drive
Chico, CA 95928-3936
P: 530-893-3779
F: 530-893-2842
E: lparks@ecst.csuchico.edu

Mr. Paul Patterson
Subcommittee on Receipts and Government Program Participation

Idaho R&E Center
1776 Science Center Drive
Idaho Falls, ID 83402-1575
P: 208-529-8376
F: 208-522-2954
E: ppatterson@ag.uidaho.edu

Dr. Ken Paxton
Chair, Committee on Receipts and Operating Costs

Department of Agricultural Economics
101 Ag Admin Bldg
Louisiana State University
Baton Rouge, LA 70803
P: 504-388-3282
F: 504-388-2716
E: akpaxt@lsuvm.sncc.lsu.edu

Dr. Tim Powell
Subcommittee on Fuel, Lube, Repairs, Custom Rates, Commodity Specific Costs and Miscellaneous

706 Douglas
Wayne, NE 68787
P: 402-375-1158

Mr. Michael Quam
Subcommittee on Fuel, Lube, Repairs, Custom Rates, Committee Specific Costs and Miscellaneous

2900 McConnell Road
Stoughton, WI 53589

Dr. Norman Rask (retired)
Subcommittee on International Comparisons

Department of Agricultural Economics
2120 Fyffe Road
The Ohio State University
Columbus, OH 43210-1067
P: 614-292-6339
F: 614-292-4749

Dr. Edward Rister
Subcommittee on Labor and Management

Department of Agricultural Economics
Blocker Bldg, 318e

Dr. Lindon Robison
Chair, Subcommittee on Land

Department of Agricultural Economics
Room 303B Ag Hall
Michigan State University
East Lansing, MI 48824-1039
P: 517-353-9172
F: 517-432-1800
E: robison@pilot.msu.edu

Dr. Carlyle Ross
Subcommittee on Labor and Management

Alberta Agriculture, Food and Rural Development
7000 113 St. #302
Edmonton, AB
Canada T6H 5T6
P: 403-427-5396
F: 403-427-5220
E: ross@agric.gov.ab.ca

Mr. John W. Ross
Subcommittee on Joint Business Costs and Rights to Produce

Appraisal Institute
875 North Michigan Avenue, Suite 2400
Chicago, IL 60611-1980
P: 312-335-4126
F: 312-335-4488

Dr. Eduardo Segarra
Subcommittee on Receipts and Government Program Participation

Dept. of Agricultural and Applied Economics
Texas Tech University
Lubbock, TX 79409
P: 806-742-2821
F: 806-742-1099
E: egseg@ttacs.ttu.edu

Texas A&M University
College Station, TX 77843-2124
P: 409-845-3801
F: 409-845-4582
E: e-rister@tamu.edu

Dr. Hosein Shapouri
Subcommittee on Fuel, Lube, Repairs, Custom Rates, Committee Specific Costs and Miscellaneous

USDA ERS RED
Room 2132
1800 M St, NW
Washington, DC 20036-5831
P: 202-694-5018
F: 202-694-5641

Dr. Stan Spurlock
Chair, Subcommittee on Seed, Fertilizer, Chemicals, Feed, Vet and Med, Purchased Livestock

Department of Agricultural Economics
316 Lloyd Ricks
PO Box 9755
Mississippi State University
Mississippi State, MS 39762
P: 601-325-7995
F: 601-325-8777
E: spurlock@agecon.msstate.edu

Mr. Michael A. Steiner
Subcommittee on Data Sources and Statistical Issues

USDA NASS IPO
Room 4151 South
1400 Independence Avenue SW
Washington, DC 20250
P: 202-720-4505
F: 202-720-0506
E: msteiner@nass.usda.gov

Dr. Tim Taylor
Subcommittee on Data Sources and Statistical Issues

Food and Resource Economics Department
University of Florida
PO Box 0240
Gainesville, FL 32611-0240
P: 352-392-1845 ext. 411
F: 352-392-3646
E: taylor@fred.ifas.ufl.edu

Mr. William Turrentine
Subcommittee on Report Structure and Content

1410 E. Hackberry
Garden City, KS 67846
P: 316-276-3890

Dr. Larry Van Tassell
Subcommittee on Seed, Fertilizer, Chemicals, Feed, Vet and Med, Purchased Livestock

Department of Agricultural Economics
University of Wyoming
PO Box 3354 Univ Station
Laramie, WY 82071
P: 307-766-2107
F: 307-766-5544
E: vant@uwyo.edu

Dr. James C. Wade
Chair, Subcommittee on Receipts and Government Program Participation

Maryland Cooperative Extension Service
College of Agriculture and Natural Resources
University of Maryland
1200 Symons Hall
College Park, MD 20742
P: 301-405-2906
F: 301-405-2963
E: jw241@umail.umd.edu

Dr. Odell Walker (retired)
Chair, Committee on Data Use and Report Structure

Department of Agricultural Economics
Oklahoma State University
Stillwater OK 70408-0505
P: 405-744-6172
F: 405-744-8210

Dr. Kelly Zering
Subcommittee on Seed, Fertilizer, Chemicals, Feed, Vet and Med, Purchased Livestock

Dept. of Agricultural and Resource Economics
Campus Box 8109
North Carolina State University
Raleigh, NC 27695-8109
P: 919-515-6089
F: 919-515-6268
E: kelly_zering@ncsu.edu

LITERATURE CITED

Adams, James D. "Permanent Differences in Unemployment and Permanent Wage Differentials." *Quarterly Journal of Economics* 100 (1985): 29-55.

Adelaja, A. O. "Price Changes, Supply Elasticities, Industry Organization, and Dairy Output Distribution." *American Journal of Agricultural Economics* 73 (1991): 89-102.

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