COST ACCOUNTING

Theory and Applications

Fischer · Frank

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PREFACE

In writing this text, we were challenged by the objective of treating the relevant issues of cost accounting in an efficient and up-to-date manner. The text, which is designed to be covered in one semester, develops a theory of analyzing profits within a firm and then integrates this concept into each chapter. Each chapter provides the student with sound theory and a logical, problem-solving approach. Common operations research and statistical tools are used whenever appropriate.

In each chapter, many illustrations and examples are used because we believe that they expedite the learning process. Also, these illustrations provide the necessary guidance for solving end-of-chapter exercises and problems. The exercises are intended to cover single concepts, while the problems are more comprehensive, often integrating several concepts.

The topical flow of the text reflects what we believe is a logical learning sequence. Chapters 1 through 3 develop the concept of how to measure profits within a firm. These chapters include discussions of cost concepts, job order and process costing techniques, and the tools of statistical analysis that are needed in subsequent chapters. Chapters 4 through 6 analyze the response of profits to changes in costs and revenues, and include the use of tools from the areas of statistics and operations research. Chapters 7 and 8 extend these tools to capital budgeting decisions, which impact on future time periods. In these chapters, the analytic tools needed for considering the acquisition of new assets and the replacement of assets are discussed. All relevant tax considerations and the effects of recent tax acts are also discussed.

Chapters 9 through 11 present the procedures for costing individual production units. Both the standard cost and the actual cost methods are fully developed, including complications caused by inventories of partially complete units and the occurrence of spoiled units. Unique scheduling approaches provide a means of solving a wide variety of problems. Chapter 12 considers the special issues for decision making and accounting that result from costs which are shared in common by several products.

Chapters 13 through 15 integrate many of the concepts of earlier chapters. Chapter 13 discusses budgeting and financial simulation models for a firm. Chapter 14 discusses transfer pricing and applies the model of analyzing profitability to measuring the performance of segments of a firm. Chapter 15 extends the tools of cost accounting to areas of quantitative analysis, including inventory control, learning curves, and critical path analysis.

A study guide, which is available as a supplemental learning tool for students, provides an outline of each chapter, followed by true-false items, multiple choice questions, and problems that are carefully structured to allow a step-by-step solution. Many of these items are taken from CPA and CMA exams.

Permission has been received from the Institute of Management Accounting of the National Association of Accountants to use questions and/or unofficial answers from past CMA examinations. Permission has also been received from the American Institute of Certified Public Accountants to use questions and/or unofficial answers from past CPA examinations.

We are grateful to the Literary Executor of the late Sir Ronald A. Fisher, F.R.S., to Dr. Frank Yates, F.R.S., and to Longman Group Ltd., London, for permission to reprint Table III, Distribution of *t*, from their book, *Statistical Tables for Biological, Agricultural and Medical Research* (6th edition, 1974).

We are most appreciative of the many students at the University of Wisconsin-Madison and the University of Wisconsin-Milwaukee for helping us test and refine our manuscript and problem materials. We especially acknowledge the work of Tom Klammer in providing significant help in developing the end-of-chapter materials. We also thank Cheryl Witt, John Arevalo, and Tom Taugher for verifying solutions. We thank posthumously the editing and typing contribution of Pearl Fischer, and we sincerely thank Nancy Taylor for completing this work.

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CONTENTS

One

Role of Cost Accounting in Decision Making

This chapter will introduce the role of accounting information in the management of a firm. It will demonstrate the types of analyses the controller provides to a firm's managers, so that they may plan and control their segments of the firm in a way that will optimize the performance of the firm. To understand the basic methods of accounting for the operations of a firm, the commonly held views of costs and revenues will be discussed in terms of their responses to the firm's volume. A theory of how to analyze profits within a firm will then be developed. This theory will become the foundation for specialized accounting procedures in subsequent chapters. Various decisions for which accounting data are crucial will be briefly studied in order to indicate the use of accounting information in the day-to-day decision making of a firm.

THE ACCOUNTANT'S VIEW OF COSTS AND REVENUES

Effective planning requires that management consider the response of a firm's costs and revenues to changes in volume. For example, a question that might be asked is, "How much will costs increase next year, if volume increases 20%?" Alternatively, management might be content with next year's projected profit, but wonders what would happen to profit if revenues fell 5% short of the projection.

Again, the behavior of costs and revenues with respect to volume must be considered.

Costs and Volume

To illustrate the relationship of costs and volume, assume that you are the cost accountant for a company that manufactures a saver switch, a device that cuts off the air conditioner in a car under heavy acceleration. You have not yet committed yourself to any production method. Economic analysis would suggest that, for any given production level, there is an optimum scale of plant that would most economically produce the switch. Optimum scale is defined as that plant size which results in the lowest average cost per unit. In Illustration 1-1, Part A, a long-run cost curve shows the monthly cost of producing various outputs, each using the appropriate scale of plant. Although the curve is not continuous, it has been drawn by connecting the alternative plant sizes. The curve is based on the common assumption that total cost increases quickly at first, then increases slowly as the optimum scale of plant is reached. Beyond the optimum scale of plant, diseconomies of scale set in and costs begin to rise more quickly. Diseconomies of scale suggest that a larger plant is inefficient and results in a higher average cost per unit. Notice that just below the graph of Part A of Illustration 1-1, the per unit costs at 3 scales of plant are calculated. The lowest average cost per unit, $5.50, occurs at plant scale B.

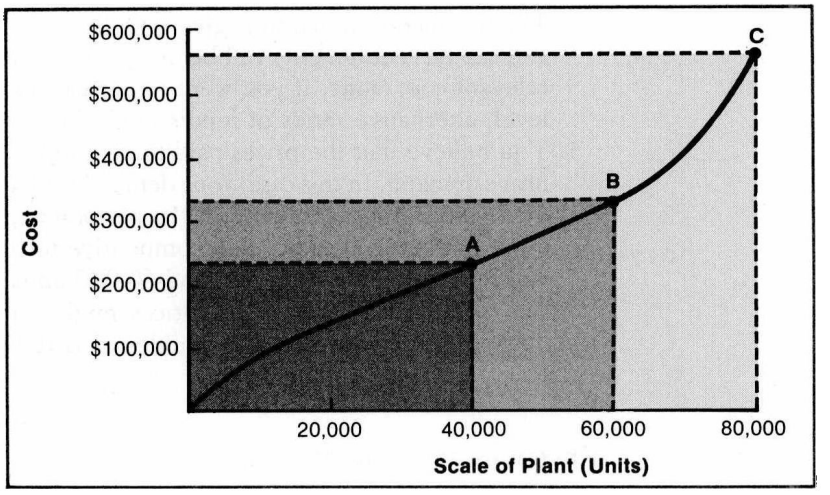
Assume that your firm builds a plant such as that suggested at scale B. Once the plant exists, you may be committed to one method of production. No longer do you have the complete freedom of action suggested by the economist's long-run cost curve. Ideally, your plant was built to produce 60,000 units per month, although it is possible to vary production about this target volume. To estimate the costs of production at other output levels, you might study the composition of costs at the 60,000-unit output. In Illustration 1-1, Part A, the predicted $330,000 cost included the following components:

Materials, .125 pounds of plastic at $16 per pound	$2
Labor, .2 hour at $10 per hour	2
Total materials and labor costs per unit	$4
Total materials and labor costs for 60,000 switches	$240,000
Add monthly cost of leasing and operating plant	90,000
Total estimated cost	$330,000

Based on this analysis, you might conclude that $90,000 of the cost will not change, even if output falls short of or exceeds 60,000 units. Such a cost is said to be **fixed** in nature. It would also appear that the remaining cost will change at the rate of $4 per unit as volume changes. Costs which respond proportionately with output are termed **variable costs.** As the accountant, your view of costs can be constructed as shown in Illustration 1-1, Part B. This graph includes a **relevant cost range** between 35,000 and 65,000 units per year. In this range, the cost function is shown as a solid line to indicate that the function is assumed to be accurate. Beyond this range, the function is shown as a broken line to indicate that the use of the function at these volumes is less accurate. The relevant cost range

Illustration 1-1
Response of Cost to Changes in Volume

Part A
Economist's View of Costs—Long-Run

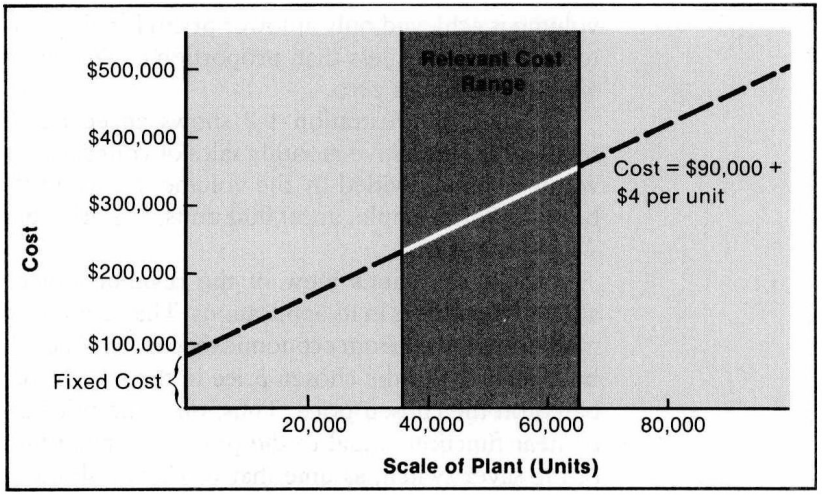


Calculation of average cost per unit:

Plant Scale	Average Cost per Unit
A	$240,000 ÷ 40,000 = $6.00
B	330,000 ÷ 60,000 = 5.50
C	560,000 ÷ 80,000 = 7.00

Illustration 1-1
Response of Cost to Changes in Volume

Part B
Accountant's View of Costs—Plant Scale B



Cost Function = $90,000 + $4 per unit

is the area in which the linear cost function, $90,000 per period plus $4 per switch, is applicable. Specifically, you would defend the cost function in this range by making the following assumptions:

1. The fixed cost of production, $90,000, will remain constant over a given range of output. However, it is likely that this cost would change at outputs beyond this range.

2. The production function is given. Only one combination of labor, materials, and capital (equipment) will be used to build the switch at volumes within the relevant cost range. If you were to depart substantially from the 60,000-unit level, alternative ratios of inputs might be used.
3. You believe that the prices paid for the inputs will not be impacted by your firm's demand. In this case, your demand for labor and materials will not affect the $10-per-hour labor cost or $16-per-pound materials cost. You assume that input markets are sufficiently competitive to be insensitive to your demands within a reasonable range around 60,000 units of output. If demand changed significantly, however, input prices might vary. For instance, input prices might react if your demand doubles or is reduced by 50%.

Revenues and Volume

To project profit at alternative volumes, management must estimate the price at which units will sell. In many cases, this process will be very subjective, since there may be little data from which to make an estimate, especially for a new product such as your saver switch. Economic theory states that, in most cases, the revenue curve for a product is a nonlinear function of units sold. This function is only viewed as linear in a market characterized by pure competition. Except in the case of the perfectly competitive market, economic theory holds that higher unit volume is achieved only at lower prices for all units sold. The response of revenue to volume is thus less than proportional. The revenue line has a declining slope, which approaches zero.

Part A of Illustration 1-2 shows an economist's possible estimate of total revenue at alternative monthly sales of your saver switch. The total revenue at any volume, when divided by the volume, results in the price at which the units will be sold. For example, at 60,000 units, the price per unit would be $6 ($360,000 ÷ 60,000 units).

The accountant's view of the revenue function is derived from economic analysis but differs in its applications. The accountant agrees that the optimum price might be derived from economic theory, but once the price is chosen, the firm may be committed to the chosen price in the short run. Price lists and promotions are based on the chosen price. Thus, once the price is established, revenue becomes a linear function, equal to the price multiplied by the units sold. In the example of the saver switch, assume that you establish the price at $6 per unit. Economic analysis already suggests that sales will be 60,000 units per month. However, you may reason that sales could vary between 40,000 and 70,000 units per month, depending on competition and economic conditions. This range could be termed the **relevant revenue range**, since it defines the range of revenue which may result from a given price.

Part B of Illustration 1-2 shows the linear revenue function. The graph indicates the most likely sales volume as provided by economic analysis. It also defines the relevant revenue range of volume that may result at a chosen price. Revenue outside the relevant revenue range is indicated by a broken line.

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Illustration 1-2
Comparison of Revenue Functions

Part A
Economist's View

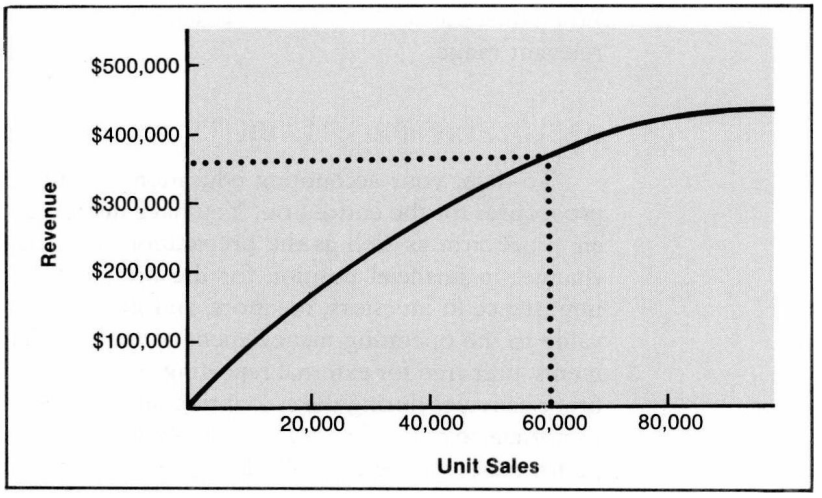
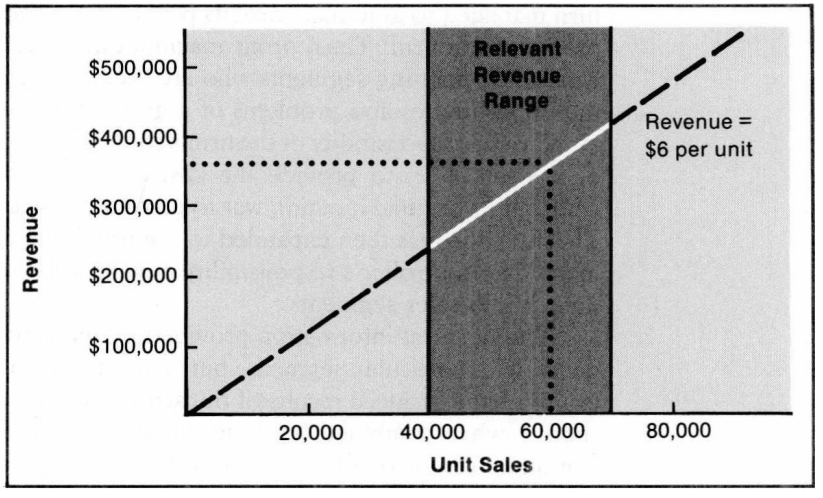


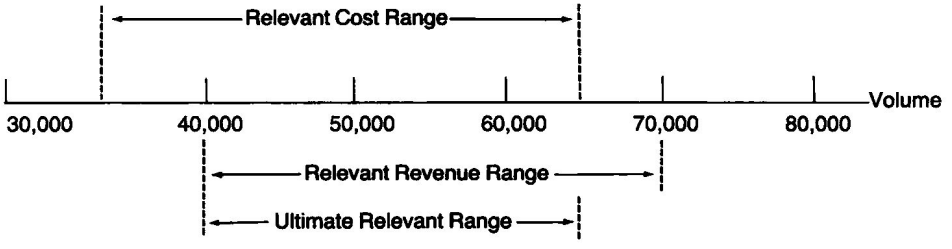
Illustration 1-2
Comparison of Revenue Functions

Part B
Accountant's View



The Ultimate Relevant Range

The following comparison of the relevant cost range with the relevant revenue range shows that they are not the same, but that there is a range of volumes satisfying the limitations of both the cost and revenue relevant ranges.



In this example, the "ultimate relevant range" is 40,000 to 65,000 units.

When the term relevant range is used in this text, it will be defined as this ultimate relevant range.

ANALYZING PROFITABILITY WITHIN THE FIRM

To date, your accounting education has probably focused on the reporting procedures for the entire firm. You have mastered the presentation of income for an entire firm as well as the preparation of a balance sheet and a statement of changes in financial position for the firm. While such statements are of prime importance to investors, creditors, and government agencies, they are of limited value to the operating management of the firm. The problem is that these statements, prepared for external reporting, report only the aggregate success of all the firm's activities during the accounting period. These statements do not analyze the performance of the firm's various segments, which are responsible for the overall performance of the firm. All firms, except very small ones, are subdivided into manageable segments such as product lines or sales territories. Each segment is in turn managed so as to maximize its performance and, in the process, maximize the profits of the firm. Thus, profit maximization may be delegated to managers of workable operating segments who are most familiar with and able to respond to the opportunities and problems of a given market.

It is the responsibility of the firm's chief accountant, often called the controller or comptroller, to provide the cost data needed by segment managers. The controller's original function was to provide financial data for external statements. This function was then expanded to the providing of data to production management. The controller's responsibility now includes the providing of cost and revenue data to sales segments.

The financial information provided by the controller must not only meet the needs of a particular segment, but it must also be capable of aggregation. For example, the financial results of the actions of product managers within a division should, when combined, indicate the financial performance of the division. The combined results of all the divisions should, in turn, measure the performance of the entire firm. The actual segments used to analyze performance should parallel the organization chart of the firm. The model used to analyze performance must be usable for planning future actions and later comparing actual performance to the plan.

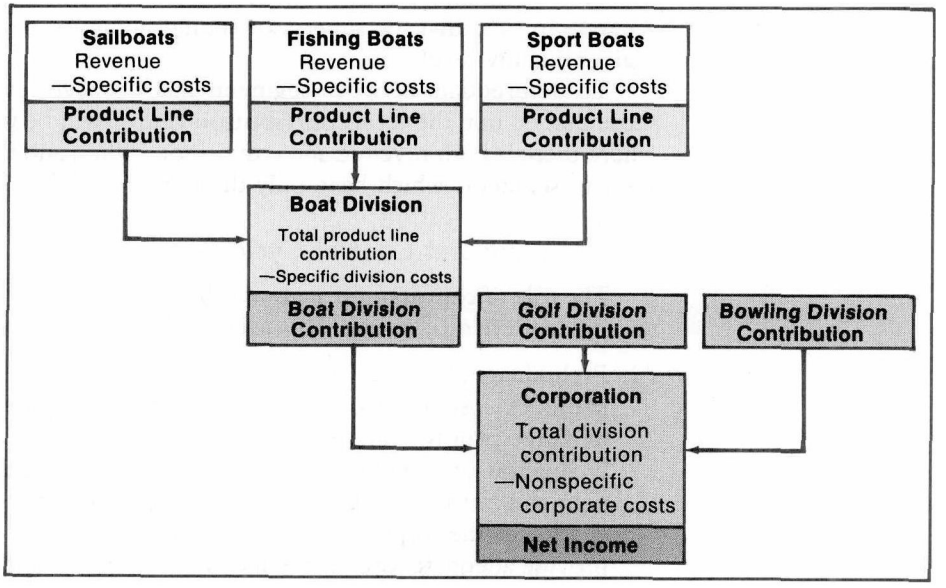
Contribution Theory

The theory of profits within a firm is based on contribution theory. This theory compares the revenue of a segment with the specific costs of a segment. Specific costs are incurred only for the segment and could be avoided if the segment were discontinued. Examples would include the labor and materials used to build a product, along with depreciation, rent, and administrative costs incurred solely for the benefit of the product. No attempt is made to charge a segment with an allocated share of costs used in common with other segments. Thus, if two product lines share a building, neither would be charged for its use. Since all segments share the use of the firm's president and staff, no segment would be charged for these salaries.

Net income implies that all of the firm's costs have been deducted from revenue. It is thus useful for measuring the performance of an entire firm. Since there will always be some common costs that will not be charged to segments, the net income concept is not readily applicable to segments. The performance of a segment can only be measured by its contribution, defined as revenue less specific segment costs.

To understand contribution analysis, assume that a firm has three divisions: boats, golf equipment, and bowling equipment. The boat division is divided into 3 main product lines: sailboats, fishing boats, and sport boats. Each product line within the boat division contributes to the boat division's contribution. Illustration 1-3 demonstrates the concept of contribution analysis for this firm.

Illustration 1-3
Contribution Analysis



The contribution of each product line is the revenue of the line less all specific costs of the line. Included would be the labor and materials used to manufacture each boat, plus costs common to all boats produced within a line. The sum of the product lines' contributions is available to cover the costs which are first specific at the division level. Such costs would include division management and the cost of the common production facilities used by all product lines. The sum of the product lines' contributions is available to cover the specific costs of the division, so that the division may make a contribution to the firm. The sum of the divisions' contributions is available to cover the costs which are first specific at the firm-wide level. Such costs would include the corporate headquarters staff as well as any other services or facilities shared by divisions. If the total contributions of the divisions is sufficient to cover these costs, there will be net income. Net income is finally calculable, since all costs are specific at the corporate level.

Illustration 1-3 does not exhaust the opportunities for contribution analysis within this firm. Very likely the contribution of each model boat to the product line's contribution would be analyzed. It is also likely that the contribution of each product line by sales territories would be studied.

The controller's measurement of the performance of segment managers should result in a keen awareness of the concept of responsibility accounting. No revenue or cost should be attached to a segment unless it is controllable by the segment's management. It is not reasonable to hold a segment responsible for revenues or costs over which it has no authority. Therefore, the management level to which contribution analysis may be applied is limited. Where there is no direct responsibility for revenue at a management level, contribution cannot be measured. Responsibility accounting requires that only costs be measured in such cases. Thus, when the performance of a supervisor in the hull molding department for sailboats is being measured, only specific costs will be considered. The direct role of the supervisor in maximizing contribution is to minimize costs. It is not prudent, however, to minimize costs without maintaining quality. Thus, it would be more accurate to state that the supervisor should minimize cost subject to maintaining a given quality level.

To differentiate between segments that do have revenue responsibility and those that do not, the term **contribution center** will be used to refer to segments where there is both revenue and cost responsibility, and the term **cost center** will refer to segments which have only direct responsibility for costs.

The Planning and Control Cycle

The role of contribution analysis is best understood by reviewing the planning and control cycle of a firm. This cycle includes the following basic steps:

1. Preliminary planning: The controller collects the needed cost information and identifies costs by segments. Each segment uses the information to build a tentative plan for future periods in order to maximize its contribution.
2. Evaluation of preliminary plans: The controller assembles the plans of the segments into a comprehensive plan for the firm. The segment plans are checked at the corporate level for compatibility. The comprehensive plan must provide adequate forecast net income for the firm and be supportable with the firm's financial resources. If a segment's plans are unacceptable, they will be returned to the segment for modification.
3. Master plan: The controller will combine final segment plans into a master budget or profit plan for the entire firm. Each segment will receive a budget which identifies that segment's responsibility for the future period.
4. Performance control: The controller will compare actual performance by each segment with that segment's budget. Variances will be studied for possible corrective action. Typically the budget will be flexible, adjusting for output levels different from the planned levels. This flexibility will allow cost analysis to be correlated to actual output.

Throughout the planning and control cycle, the focus is on maximizing the firm's profit by maximizing the contribution of each segment. Management must, however, be careful to identify possible opportunities for suboptimization. Suboptimization occurs when a segment maximizes its contribution in such a manner that the overall profit of the firm is reduced. In other words, the increase in one segment's contribution is more than offset by another segment's loss of contribu-

tion. In the previous illustration, for example, each dealer might be required to place a large minimum order of fishing boats, which could increase the sales of fishing boats at the expense of sail and sport boat sales. Another example might be that of a production supervisor eliminating the final cleanup of boats to minimize costs, which could result in dealers reducing their purchases to the point that the reduction in cost is more than offset by a loss in revenue. One of the functions performed in the evaluation of preliminary plans is the identification and elimination of obvious cases of suboptimization.

GUIDELINES FOR DECISION MAKING

The discussion so far has centered on the overall performance of a segment. It should be obvious that the performance of the segment reflects the quality of the individual decisions concerning the operations of the segment. It is therefore important that the controller provide segment decision makers with the data needed to aid their analysis and to make wise decisions. Analytic models should be available for use when the decision being studied will have a material impact on the segment's contribution. Major examples of decisions that require financial evaluation would include the acquisition of new equipment, entering new sales territories, marketing new products, dropping existing products, and buying parts from outside suppliers rather than continuing to manufacture the parts. Many of these decisions will impact on several future periods. For example, a machine purchased today may provide labor savings for 10 years. If the machine costs $6,145, and the labor savings are $1,000 per year, is the investment wise? It is not appropriate to compare the total savings of $10,000 ($10 \times \$1{,}000$) to the $6,145 cost, because the interest that could be earned on the $6,145 investment is being ignored. The $1,000 per year must be viewed as a return of the $6,145 investment plus interest on the investment. By using capital budgeting techniques, discussed in Chapter 7, the interest on the investment can be computed. If the interest rate provides a sufficient return, the investment should be made; if not, the acquisition should be vetoed.

There are several general guidelines for analyzing major decisions. These guidelines, which will be explained in detail and demonstrated in later chapters, are as follows:

1. Decisions should recognize the uncertainty inherent in estimates of future results, such as how many units will be sold or what future labor rates will be. It is tempting to just incorporate one best estimate into the analysis, but this procedure is dangerous. Instead, possible alternative estimates should be considered. For example, the one best estimate might be replaced with a weighted average estimate, which would be based on several estimates weighted by their likelihood of occurring. Another alternative would be to determine how sensitive the decision is to the correctness of the estimates. If projected sales are off by 10%, would the same decision still be made? Such evaluations are called **sensitivity analysis.**
2. Decisions should incorporate the effect of variations in volume and future costs. If, for example, a new product is being considered, its production cost

must be estimated. Since sales may vary from period to period, the cost of production should be stated in a way that allows adjustment for alternative volumes. Therefore, a knowledge of cost behavior—the response of costs to changes in volume—is necessary. Typically there are some costs, called **fixed costs**, that do not respond to changes in volume and are estimated at a given amount per period. Other costs, called **variable costs**, change with volume and are estimated as a cost per unit of output.

3. For decision-making purposes, the cost of a unit of output should be only the variable costs that would have been saved if that single unit had not been built. Even though a fixed cost is specific to a product, there is no reason to state cost on a per-unit-of-output basis, except to comply with external accounting requirements. To understand this concept, assume that a donut shop rents an automated donut maker for $600 per month and that the materials cost $.05 per donut. The per unit cost of a donut, for decision purposes, is $.05. If the cost of a unit were to include the $600 per month, dividing by expected output would be necessary. If sales are estimated at 5,000 donuts per month, the rent per donut would be $.12. This $.12 would be the allocated fixed cost per unit, but it should not be considered for future decision processes, because the $600 per month is a common cost of all units. For example, assume that a one-time contract to sell 1,000 extra donuts at $.08 is available. The decision to produce the 1,000 additional donuts should be based on the contribution of these donuts, that is, the difference between the additional revenue of $.08 per donut and the additional cost of $.05 per donut. The order would thus contribute $30 ($.03 × 1,000) toward covering the $600 per month fixed cost.
4. If decisions involve assets currently owned, the opportunity cost of these assets must be considered. The historical cost is not usually relevant. **Opportunity cost** is the value of the asset in its most profitable alternative use. In other words, if the asset is not used for the decision, what is the most profitable use for the asset and what is it worth in that use? Consider the following examples.
   a. The replacement of an existing machine is being considered. If it is replaced, the most advantageous action is to sell the old machine. The opportunity cost is the old machine's market value.
   b. The discontinuance of a manufacturing operation is being considered. A building would no longer be needed. It would be more profitable to rent out the building than to sell it. The opportunity cost is the rental value.
   c. It is nearing the end of the year, and a book publisher has in stock 1,000 current-year tax guides that cost $10 a book to produce. The publisher has an opportunity to sell the books for $2 each to a foreign university desiring a "feel" for U.S. taxation. The only other option is to sell the books to a paper recycler for $.10 each. The opportunity cost used to consider the foreign university's offer is $.10 per book, which is the only alternative opportunity.
5. For any decision, only those costs and revenues that will change from their current levels should be considered. Including costs and revenues that will not change complicates and confuses the analysis. For example, assume that a major automobile manufacturer is considering the building of a limited production convertible. It could compare the entire future corporate income

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