|  |  |
| --- | --- |
|  | **Determining How Costs Behave** |
|  |  |

**Transition Notes**

The five-step decision model is applied in this chapter to evaluate changes in costs and how these affect the chosen cost drivers. There is a greater discussion of managerial decision making using quantitative analysis. The appendix on regression analysis has been expanded. Additional material relating to ABC/ABM is included. Several new problems are introduced in the end-of-chapter material and many have been revised.

|  |
| --- |
| **Problem Material**  **Correlation Chart** |

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | **15th**  **Edition** | **14th**  **Edition** |  | **15th**  **Edition** | **14th**  **Edition** |
|  | 16 | 16 |  | 30 | 30 Revised |
|  | 17 | 17 |  | 31 | 31 Revised |
|  | 18 | 18 |  | 32 | 32 Revised |
|  | 19 | 19 |  | 33 | 33 Revised |
|  | 20 | 20 Revised |  | 34 | 34 Revised |
|  | 21 | 21 Revised |  | 35 | 35 Revised |
|  | 22 | 22 Revised |  | 36 | 36 Revised |
|  | 23 | 23 Revised |  | 37 | 37 Revised |
|  | 24 | 24 Revised |  | 38 | 38 Revised |
|  | 25 | 25 Revised |  | 39 | 39 Revised |
|  | 26 | 26 Revised |  | 40 | 40 Revised |
|  | 27 | 27 Revised |  | 41 | 41 Revised |
|  | 28 | 28 Revised |  | 42 | 42 Revised |
|  | 29 | 29 Revised |  | 43 New |  |

1. **LEARNING OBJECTIVES**
2. Describe linear cost functions and three common ways in which they behave.
3. Explain the importance of causality in estimating cost functions.
4. Understand various methods of cost estimation.
5. Outline six steps in estimating a cost function using quantitative analysis.
6. Describe three criteria used to evaluate and choose cost drivers.
7. Explain nonlinear cost functions, in particular, those arising from learning curve effects.
8. Be aware of data problems encountered in estimating cost functions.
9. **CHAPTER SYNOPSIS**

Chapter 3 discussed cost-volume-profit analysis and the relationship among costs, profits, and activity levels. This chapter presents concepts and methods that can be utilized to analyze mixed costs and to break them into separate fixed and variable components. Managers use cost functions to gain a better understanding of cost behavior. **Cost functions** are mathematical formulas that describe how costs behave relative to changes in activity levels. Two key assumptions often made by managers using cost functions are:

1. Changes in activity levels explain changes in total costs.
2. Cost behavior in the relevant range can be estimated with a linear function.

The chapter also presents alternative cost functions that do not rely on these two assumptions. Regression analysis is discussed in greater detail in the Appendix.

**III. Points of Emphasis**

1. Make certain the students understand the assumptions in cost behavior limitations. These are limiting assumptions and must be taken into account.
2. Emphasize that the equation for a cost function, , is the universal; it applies for all methods of cost estimation. Also make sure the students know the mathematical names, as well as the cost accounting names, for each element in the equation.
3. Make sure that the students understand that fixed, variable, and mixed are descriptions of cost behaviors and that they understand their behavior on a per-unit basis as well as total.
4. As accountants, we naturally have a preference for quantitative methods of estimating a cost function. Emphasize that high-low is simple, but that computers have made regression accessible to everyone. They do not need to understand how to compute a regression equation, but they should be able to interpret the results.
5. It is not so important to get into the mathematical details of the learning curve, but be sure the students understand the reality and application of learning curves.
6. Help the students realize that data does not always come to them in neat packages as shown in the text, but emphasize data collection problems.
7. **CHAPTER OUTLINE**

|  |  |
| --- | --- |
| **LEARNING**  **OBJECTIVE** | 1 |
| Describe linear cost functions  … graph of cost function is a straight line  and three common ways in which they behave  … variable, fixed, and mixed | |
|  | |

* + 1. Understanding how costs behave is a valuable technical skill. A management accountant must be able to identify cost drivers, estimate cost relationships, and determine the fixed and variable components of costs. In order to effectively do this, the management accountant must have an understanding of the operations of the business, be a vital member of the management team, and be able to convey his or her findings.

1.2 A **cost function** is a mathematical description of how a cost changes with changes in the level of an activity relating to that cost.

* 1. Managers often estimate cost functions based on two assumptions:
* Variations in the level of a single activity (cost driver) explain the variations in the related total costs.
* Costs behave in a linear manner within the relevant range of activity. A **linear cost function** is represented by a straight line.

Teaching point. These assumptions may not always be fulfilled. However, in many instances, they meet the criteria closely enough to allow for useful analysis.

1.4 The formula for a cost function is . These components will be discussed as we progress through the chapter.

|  |  |
| --- | --- |
| **LEARNING**  **OBJECTIVE** | 2 |
| Explain the importance of causality in estimating cost functions  … without a cause and effect relationship, managers will be less confident about their ability to predict costs | |
|  | |

2.1 Costs usually behave in one of three commonly encountered manners. They can be variable, fixed, or semivariable.

2.2 A **variable cost function** represents a cost that increases in total as the level of the cost driver increases. The amount by which the cost increases as the cost driver increases by one is the **slope coefficient,** represented by *b* in the equation for a cost function.

2.3 A **fixed cost function** is one in which the cost does not change in response to changes in the level of activity. It is referred to as the **constant,** and is represented by *a* in the equation.

2.4 A **mixed cost** function represents a cost that has both variable and fixed components. This is also known as a **semivariable cost.**

(Exhibit 10-1 displays examples of linear cost functions.)

Teaching point. It is good to illustrate the three concepts at this point. A good example may be the situation of renting a car. In theory, the car rental agency can present three options: (1) A flat rate per day, such as $50. The rental cost will be fixed at $50, regardless of miles driven. (2) A per mile rate, such as $1.00 for each mile driven. The rental cost will be variable based on the number of miles driven. (3) A mixed rate, such as $25 per day plus $0.50 per mile driven. The rental cost will be a fixed $25 a day plus an increasing amount for each mile driven.

2.5 From Chapter 2, there are three criteria for classifying a cost into its fixed and variable components. It will be helpful to review these three concepts at this point.

* **Choice of Cost Object.** Depending on the choice of the cost object a given cost may be fixed or variable.
* **Time Horizon.** Whether a cost is fixed or variable for a particular activity may depend on the time horizon being considered in the decision. The longer the time frame, the more costs become variable.
* **Relevant Range.** Cost behavior patterns are valid for linear cost functions only within the given relevant range. Outside this range, cost behavior patterns change causing the costs to become nonlinear.

(Exhibit 10-2 illustrates linearity within a relevant range.)

**Refer to Quiz Question 1 Exercises 10-17, 10-18, and 10-19**

|  |  |
| --- | --- |
| **LEARNING**  **OBJECTIVE** | 3 |
| Understand various methods of cost estimation  … for example, regression analysis (a quantitative analysis method) determines the line that best fits past data | |
|  | |

3.1 Managers use **cost estimation** to measure a relationship based on data from past costs and the related level of an activity.

3.2 Estimating these past cost functions can help managers make more accurate **cost predictions** about future costs.

3.3 Critical to this process is correctly identifying the factors that affect costs. Managers, then, are looking for a cause-and-effect relationship between the costs incurred and the level of activity. We refer to this activity measure as a **cost driver.**

3.4 The cause-and-effect relationship may arise as a result of:

* **A physical relationship between the level of activity and costs.** There is a physical relationship between direct materials and the number of units produced.
* **A contractual arrangement.** For example, in a car rental contract that charges by the mile, miles driven is specified in the contract as the activity that affects the rental cost.
* **Knowledge of operations.** A product with many parts will incur higher ordering costs than a product with few parts. If the company is measuring ordering costs, the activity driver could be number of parts.

3.5 There are several different methods for estimating costs. These methods include:

* The **industrial engineering method,** also called the **work-measurement method,** estimates cost functions by analyzing the relationship between inputs and outputs in physical terms. This is a thorough and detailed method, but can be very time-consuming.
* The **conference method** estimates cost functions based on analysis and opinions about costs and their drivers gathered from various departments of a company. Because it does not require detailed analysis of data, it can be used to develop cost functions very quickly. However, the emphasis on opinions rather than systematic estimation can make this a less accurate method.
* The **account analysis method** estimates cost functions by classifying various cost accounts as variable, fixed, or mixed with respect to the identified level of activity. Although this method relies more on qualitative analysis, it is reasonably accurate, cost-effective, and easy to use.
* The **quantitative analysis method** uses formal mathematical models to fit cost functions to past data observations. The most common quantitative analysis methods are the high-low method and regression analysis.

**Refer to Quiz Question 2 Exercises 10-20 and 10-21**

|  |  |
| --- | --- |
| **LEARNING**  **OBJECTIVE** | 4 |
| Outline six steps in estimating a cost function using quantitative analysis  … the end result (step 6) is to evaluate the cost driver of the estimated cost function | |
|  | |

4.1 Estimating a cost function using quantitative analysis involves a six-step procedure:

**Step 1:** **Choose the dependent variable** (cost being estimated or predicted). The **dependent variable** is the cost being estimated (*y* in the equation) and depends on the cost function being estimated.

**Step 2:** **Identify the independent variable, or cost driver.** The **independent variable** is the factor used to predict the cost function. This is the cost driver, otherwise referred to as *X* in the equation, or the slope. The cost driver should be measurable and have an economically plausible relationship to the dependent variable.

Teaching point. Beware of spurious relationships. Just because a relationship between the dependent and independent variable exists does not mean that there is a cause-and-effect relationship in place. Point out that you can prove (statistically) that drinking water is fatal; that is, 100 percent of people who drink water die. Obviously, there is no relationship between mortality and drinking water.

**Step 3:** **Collect data on the dependent variable and the cost driver.** This is usually the most difficult step, as the data comes from a number of sources, and managers need to be concerned about the validity of the data.

**Step 4:** **Plot the data.** By plotting the data on a scattergraph it can be determined if a linear relationship exists. Also, this alerts the manager to any extreme observations.

(Exhibit 10-4 is an example of this step, with data plotted on the graph.)

**Step 5:** **Estimate the cost function.** As mentioned, there are two primary methods of estimating a cost function—the high-low method and regression analysis.

**Step 6:** **Evaluate the cost driver of the estimated cost function.** Evaluation of the cost driver is discussed later in the chapter.

4.2 The **high-low method** is the simplest form of quantitative analysis. This method estimates the slope coefficient and the constant of the cost function using the high and low levels of activity and the costs and the costs incurred at each level.

Teaching point. At this juncture the high-low method should be illustrated by working through a problem. Exercise 10-23 is a good illustration of this method. Be certain the students understand that you select the high and low activity levels and not the high and low levels of cost.

(Exhibit 10-5 illustrates an estimated cost function using the high-low method.)

4.3 Advantages of the high-low method are that it is simple to compute and understand, and it can give a quick insight into cost-activity relationships. However, it utilizes only two data points, thus ignoring a great deal of valid data.

4.4 **Regression analysis** is a statistical technique that measures the average amount of change in the dependent variable associated with a unit change in the independent variable. This method requires the use of statistical software but will usually give the most accurate results.

4.5 **Multiple regression** allows the manager to incorporate multiple cost drivers in the analysis to help explain the changes in costs as the activity level changes.

4.6 In a regression analysis, the **residual term** measures the distance between the actual and estimated costs for each observation. The *r*2 value is an indication of how good a predictor of costs the equation is. This is referred to as *goodness of fit.*

(Exhibit 10-6 illustrates a least-squares regression line.)

**Refer to Quiz Questions 3, 4, and 5 Exercises 10-23, 10-24, and 10-27**

|  |  |
| --- | --- |
| **LEARNING**  **OBJECTIVE** | 5 |
| Describe three criteria used to evaluate and choose cost drivers  … economically plausible relationships, goodness of fit, and significant effect of the cost driver on costs | |
|  | |

5.1 One of the difficulties in applying a model to predict costs is determining how effective the model is in making those predictions. Under any of these models, the data can be entered and a prediction equation derived. Is this the best cost driver to predict the behavior? How good is this driver at predicting cost behavior?

5.2 There are three criteria often used to evaluate cost drivers; they are:

* **Economic plausibility.** Do the cost driver and the level of costs seem to be related? Does it make sense that an increase in the independent variable will cause an increase in the costs?
* **Goodness of fit.** Are the differences between the actual costs and predicted costs small? In a regression analysis, goodness of fit is measured by the *r*2 statistic.
* **Significance of independent variable.** If the regression line (or total cost line) has a steep slope, this indicates a strong relationship between the cost driver and the costs incurred.

(Exhibits 10-7 and 10-8 illustrate the use of alternative cost drivers for cost estimation purposes.)

5.3 As has been discussed in a previous chapter, activity-based costing focuses on individual activities. To implement ABC a cost driver must be identified for each activity.

* As a result, ABC systems have a large number of cost drivers and cost pools, requiring many cost relationships to be estimated. As a part of this process, the manager must pay careful attention to the cost hierarchy (unit, batch, product, or factory level).

**Refer to Quiz Question 6 Problem 10-34**

|  |  |
| --- | --- |
| **LEARNING**  **OBJECTIVE** | 6 |
| Explain nonlinear cost functions,  … graph of cost function is not a straight line, for example, because of quantity discounts or costs changing in steps  in particular, those arising from learning curve effects | |
|  | |

6.1 Costs do not always behave in a neat, orderly, linear fashion. A **nonlinear cost function** is one in which the graph of the total costs based on the level of a single activity is not a straight line within the relevant range.

6.2 Economies of scale may prevent a cost from behaving in a linear fashion. When a larger number of items are ordered, the price per unit may decline.

6.3 *Step cost functions* are another example of nonlinear cost functions. These remain the same over certain ranges of activity, but increase from one range to the next.

6.4 A *step variable-cost* *function* has a narrow range in which the cost remains the same, whereas a *step fixed-cost function* changes over a wider range of costs.

Teaching point. Illustrate step functions with examples. For example, the company requires one supervisor for every 20 workers. If they have 100 workers, there will be five supervisors. New supervisors would be hired only as 20 additional workers are employed.

(Exhibit 10-9 displays the effect of quantity discounts and nonlinear cost functions.)

* 1. Nonlinear cost functions result from **learning curves.** A learning curve is a function that measures how labor-hours per unit decline as units of production increase. This occurs because workers are learning and becoming better at their jobs. An **experience curve** is a broader application of the learning curve which measures the decline in costs per unit in other functions of the value chain.
  2. In the **cumulative average-time learning model,** the cumulative average time per unit decreases by a constant percentage each time the cumulative quantity produced doubles. With an 80 percent learning curve, if the quantity produced doubles, the average time for all units produced drops to 80 percent of the previous time.

(Exhibit 10-10 illustrates the cumulative average-time learning model.)

* 1. In the **incremental unit-time learning model,** the incremental time needed to produce the last unit declines by a constant percentage each time the quantity of units produced doubles. An 80 percent learning curve under this model means that when unit production doubles, the time needed to produce the last unit is 80 percent of the time needed to produce the last unit before production doubled.

(Exhibit 10-11 illustrates the incremental unit-time learning model.)

(Exhibit 10-12 plots costs using learning curves at Rayburn Corporation.)

* 1. In setting prices, preparing budgets, and determining standards, a company needs to consider the learning curve effect. As production increases to meet demand, cost per unit decreases. These factors must be considered in the company’s planning process.

(Exhibit 10-13 illustrates the learning effect on costs at Rayburn Corporation.)

TEACHING POINT. Observe that this is one reason why custom products are more expensive—because they are unique, there is no learning curve effect.

**Refer to Quiz Questions 7, 8, and 9 Problem 10-28 and 10-29**

|  |  |
| --- | --- |
| LEARNING  OBJECTIVE | 7 |
| Be aware of data problems encountered in estimating cost functions  … for example, unreliable data and poor recordkeeping, extreme observations, treating fixed costs as if they are variable, and a changing relationship between a cost driver and cost | |
|  | |

7.1 The ideal database for estimating cost functions quantitatively has two characteristics:

* The database should contain numerous, reliably measured observations of the cost driver (the independent variable) and the related costs (the dependent variable).
* The database should include many values spanning a wide range for the cost driver.

7.2 Because the ideal database does not usually present itself, the cost analyst should be aware of several frequently encountered problems and actions that can be taken to overcome the problems.

* The time period for measuring the dependent variable may not match the period for measuring the cost driver. Keeping records on the accrual basis will facilitate these comparisons.
* Fixed costs are allocated as if they are variable. To avoid this problem, take care to distinguish between fixed and variable costs and do not treat unitized fixed cost as a variable cost.
* Data are either not available for all observations or are not uniformly reliable. This is a collection issue; to overcome the problem data should be obtained on a regular basis with follow up when data are missing.
* Extreme values of observations occur from errors in recording costs. Adjust or eliminate unusual values before estimating a relationship.
* There is no homogeneous relationship between the cost driver and the individual cost items in the pool. This can be overcome with additional cost pools or with multiple regression analysis.
* The relationship between the cost driver and the cost is not stationary. This can occur when there is a change in operations. Splitting the data into “before and after” pools and estimating separate cost relationships may facilitate understanding.
* Inflation has affected costs, the cost driver, or both. Removing the inflationary effects through the use of a price index may assist the analyst.

**Refer to Quiz Question 10**

**V. OTHER RESOURCES**

To download these and other resources, visit the Instructor’s Resource Center [*www.pearsonhighered.com*](http://www.pearsonhighered.com/).

The following exhibits were mentioned in this chapter of the Instructor’s Manual, and have been included in the **PowerPoint Lecture presentation** created specifically for this chapter. You may use the PowerPoint Lecture presentations “as is”, or modify them to suit your individual needs.

Exhibit 10-1 displays examples of linear cost functions.

Exhibit 10-2 illustrates linearity within a relevant range.

Exhibit 10-4 is an example of a step 4 scattergraph, with data plotted on the graph.

Exhibit 10-5 illustrates an estimated cost function using the high-low method.

Exhibit 10-6 illustrates a least-squares regression line.

Exhibits 10-7 and 10-8 illustrate the use of alternative cost drivers for cost estimation purposes.

Exhibit 10-9 displays the effect of quantity discounts and nonlinear cost functions.

Exhibit 10-10 illustrates the cumulative average-time learning model.

Exhibit 10-11 illustrates the incremental average-time learning model.

Exhibit 10-12 plots costs using learning curves at Rayburn Corporation.

Exhibit 10-13 illustrates the learning curve effect on costs at Rayburn Corporation.

Download pdf images of textbook illustrations and exhibits from the **Image Library** or access them via your IR-DVD.

**CHAPTER 10 QUIZ**

1. A mixed cost function has a constant component of $20,000. If the total cost is $60,000 and the independent variable has the value 200, what is the value of the slope coefficient?

a. $200

b. $400

c. $600

d. $40,000

1. [CMA Adapted] Of the following methods, the one that would *not* be appropriate for analyzing how a specific cost behaves is
2. the scattergraph method.
3. the industrial engineering approach.
4. linear programming.
5. statistical regression analysis.
6. When the high-low method is used to estimate a cost function, the variable cost per unit is found by
7. performing regression analysis on the associated cost and cost driver database.
8. subtracting the fixed cost per unit from the total cost per unit based on either the highest or lowest observation of the cost driver.
9. dividing the difference between the highest and lowest observations of the cost driver by the difference between costs associated with the highest and lowest observations of the cost driver.
10. dividing the difference between costs associated with the highest and lowest observations of the cost driver by the difference between the highest and lowest observations of the cost driver.

**The following data apply to questions 4 and 5.**

Tory Company derived the following cost relationship from a regression analysis of its monthly manufacturing overhead cost.

*y* = $80,000 + $12*X* where: *y* = monthly manufacturing overhead cost

*X* = machine-hours

The standard error of estimate of the regression is $6,000.

The standard time required to manufacture one six-unit case of Tory’s single product is four machine-hours. Tory applies manufacturing overhead to production on the basis of machine-hours, and its normal annual production is 50,000 cases.

1. [CMA Adapted] Tory’s estimated variable manufacturing overhead cost for a month in which scheduled production is 10,000 cases would be

a. $80,000.

b. $480,000.

c. $160,000.

d. $320,000.

1. [CMA Adapted] Tory’s predetermined fixed manufacturing overhead rate would be

a. $4.80/MH.

b. $4.00/MH.

c. $3.20/MH.

d. $1.60/MH.

1. Three criteria to use in identifying cost drivers from the potentially large set of independent variables that can be included in a regression model are
2. goodness of fit, size of the intercept term, and specification analysis.
3. independence between independent variables, economic plausibility, and specification analysis.
4. economic plausibility, goodness of fit, and significance of independent variable.
5. spurious correlation, expense of gathering data, and multicollinearity.
6. Companies that take advantage of quantity discounts in purchasing their materials have
7. decreasing cost functions.
8. linear cost functions.
9. nonlinear cost functions.
10. stationary cost functions.
11. With the cumulative average-time learning model
12. the cumulative time per unit declines by a constant percentage when production doubles.
13. the time needed to produce the last unit declines by a constant percentage when production doubles.
14. costs increase in total by a constant percentage as production increases.
15. the total cumulative time increases in proportion to production increases.
16. When using the incremental unit-time learning model
17. the cumulative time per unit declines by a constant percentage when production doubles.
18. the time needed to produce the last unit declines by a constant percentage when production doubles.
19. the time to produce one additional unit decreases by a constant percentage.
20. costs increase incrementally in an undetermined pattern.
21. Which of the following is *not* a common problem encountered in collecting data for cost estimation?
22. Lack of observing extreme values
23. Missing data
24. Changes in technology
25. Distortions resulting from inflation

**CHAPTER 10 QUIZ SOLUTIONS**

# 1. a

# 2. c

# 3. d

# 4. b

# 5. d

# 6. c

# 7. c

# 8. a

# 9. b

# 10. a

#### Quiz Question Calculations

1. Total cost $60,000 40,000

Fixed cost 20,000 200 units = $200/unit (variable cost)

Variable cost 40,000

4. *y* = 80,000 + 12*X*

Variable cost = (10,000 cases × 4 machine hours/case × $12/machine hour)

Variable cost = $480,000

5. Fixed costs = $80,000 = $0.40/ machine hour

Machine hours 50,000 × 4

$0.40/ machine hour × 4mh/unit = $1.60