Module 15

Cost Behavior, Activity Analysis, and Cost Estimation

Learning Objectives

LO1 Identify basic patterns of how costs respond to changes in activity cost drivers. (p. 15-3)

LO2 Determine a linear total cost estimating equation. (p. 15-6)

LO3 Calculate and compare three different approaches to cost estimation. (p. 15-11)

LO4 Identify and discuss problems encountered in cost estimation. (p. 15-17)

LO5 Describe and develop alternative classifications for activity cost drivers. (p. 15-18)

Square, Inc.
www.squareup.com

The creator of **Twitter**, Jack Dorsey, founded **Square, Inc.** in 2009 to address a void in payment processing services for small, portable businesses. Square makes a postage stamp-sized plastic card reader that attaches to smartphones, which gives businesses such as food trucks, kiosk boutiques, taxi drivers, and the like the ability to accept credit card payments. Square also has an online payment app, and in 2016, Square introduced Virtual Terminal, which enables sellers to accept payments from their computers through the Square Dashboard.

The San Francisco–based company has been so successful that it now processes over $40 billion in transactions each year. Square provides the card readers, the Dashboard App, and the Virtual Terminal to businesses free of charge but collects a per transaction fee to compensate for its services.

In recent years, Square has expanded beyond payment processing to offer a broad range of services, including marketing, analytics, and payroll. With Square's hand in so many business lines coupled with the company's phenomenal growth, it's difficult for outsiders and insiders, including Square's management team, to predict future costs. This is an important task because the company's growth plans require either internally generated profit or external financing to continue on its trajectory.

The cost of making the card readers is directly related to the number of new businesses adopting the technology. In other words, the hardware cost is driven by the number of new merchants in any given period. But the number of new adoptions is difficult to estimate in advance. The costs associated with processing payments are even more difficult to predict. Consider that the company remits most of the payments received from customers' credit card companies to the merchant, minus Square's fee. However, what is Square's cost of processing each payment? Does the cost of processing a payment differ based on volume or seasonality?

In order to predict processing costs, we must be able to predict merchant sales volume or number of transactions. If the processing costs vary proportionately with this activity, the processing costs are referred to as variable costs. And what about the costs that do not vary with the number or type of transactions processed? Many of Square's employees are salaried engineers and software developers. These costs are likely to be unrelated to the number of card readers issued or payments processed. We call costs that do not vary with activity fixed costs. As we'll see throughout the module, many costs are neither variable nor fixed, but a mixture of the two. Mixed costs present a challenge to a company in estimating future costs.

Square needs the ability to accurately predict its future costs if it is to maintain the financial flexibility necessary to go up against its competitors. This requires a thorough understanding of cost behavior, activity analysis, and cost estimation, which are the topics of this module.

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Road Map

LO	Learning Objective | Topics	Page	eLecture	Guided Example	Assignments
15-1	**Identify basic patterns of how costs respond to changes in activity cost drivers.** Cost Behavior Patterns :: Variable Costs :: Fixed Costs :: Mixed Costs :: Step Costs :: Factors Affecting Cost Behavior	15-3	e15-1	Review 15-1	11, 12, 13, 14
15-2	**Determine a linear total cost estimating equation.** Total Cost Function :: Relevant Range :: Economic vs Accounting Cost Structures :: Additional Cost Behavior Patterns :: Committed and Discretionary Fixed Costs	15-6	e15-2	Review 15-2	13, 14, 15, 16, 17, 19, 20, 21, 22, 23, 24, 25
15-3	**Calculate and compare three different approaches to cost estimation.** High-Low Cost Estimation :: Scatter Diagrams :: Least Squares Regression	15-11	e15-3	Review 15-3	13, 14, 18, 19, 20, 21, 22, 23, 24, 25, 29, 30, 33, 34, 35
15-4	**Identify and discuss problems encountered in cost estimation.** Additional Issues :: Changes in Technology and Prices :: Matching Activity and Costs :: Identifying Activity Cost Drivers	15-17	e15-4	Review 15-4	31
15-5	**Describe and develop alternative classifications for activity cost drivers.** Alternative Classifications :: Manufacturing Cost Hierarchy :: Customer Cost Hierarchy	15-18	e15-5	Review 15-5	26, 27, 28, 32

Module Organization

Cost Behavior, Activity Analysis, and Cost Estimation

Organization

Cost Behavior, Activity Analysis, and Cost Estimation

Cost Behavior Analysis	Cost Estimation	Additional Issues in Cost Estimation	Alternative Cost Driver Classifications
■ Four Basic Cost Behavior Patterns ■ Factors Affecting Cost Behavior Patterns ■ Total Cost Function for an Organization or Segment ■ Relevant Range ■ Additional Cost Behavior Patterns ■ Committed and Discretionary Fixed Costs	■ High-Low Cost Estimation ■ Scatter Diagrams ■ Least-Squares Regression	■ Changes in Technology and Prices ■ Matching Activity and Costs ■ Identifying Activity Cost Drivers	■ Manufacturing Cost Hierarchy ■ Customer Cost Hierarchy

Cost Behavior Analysis

eLectures MBC **LO1** Identify basic patterns of how costs respond to changes in activity cost drivers.

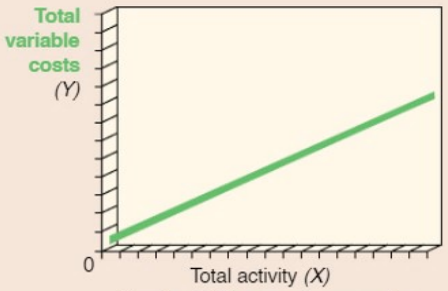
This module introduces **cost behavior**, which refers to the relationship between a given cost item and the quantity of its related cost driver. Cost behavior, therefore, explains how the total amount for various costs responds to changes in activity volume. Understanding cost behavior is essential for estimating future costs. In this module we examine several typical cost behavior patterns and methods for developing cost equations that are useful for predicting future costs.

Four Basic Cost Behavior Patterns

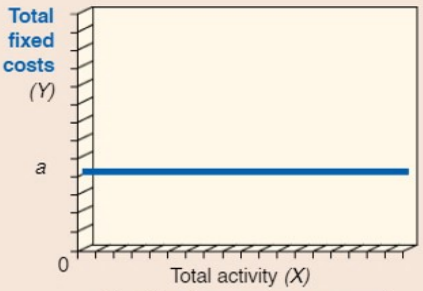
Although there are an unlimited number of ways that costs can respond to changes in cost drivers, as a starting point it is useful to classify cost behavior into four categories: **variable costs**, **fixed costs**, **mixed costs**, and **step costs**. Graphs of each are presented in Exhibit 15.1. Observe that total cost (the dependent variable) is measured on the vertical axis, and total activity (the independent variable) is measured on the horizontal axis. Consider pizza franchise **Papa Murphy's Pizza**. Papa Murphy's specializes in "take and bake," meaning they are made to order and cooked in the customer's oven at home. Customers can pick from signature pies like Chicken Artichoke and Spicy Fennel Sausage, or they can create their own and choose the type of dough, sauce, and toppings. Papa Murphy's scores top marks for customer satisfaction and expects to see significant growth over the next few years. To manage its growth, the company must understand the behavior underlying its cost structure.

1. **Variable costs** change in total in direct proportion to changes in activity. Their total amount increases as activity increases, equaling zero dollars when activity is zero and increasing at a constant amount per unit of activity. The higher the variable cost per unit of activity, the steeper the slope of the line representing total cost. With the number of pizzas served as the activity cost driver for Papa Murphy's restaurants, the cost of cheese is an example of a variable cost.
2. **Fixed costs** do not change in response to a change in activity volume. Hence, a line representing total fixed costs is flat with a slope (incline) of zero. With the number of Papa Murphy's pizzas sold as the activity cost driver, annual depreciation, property taxes, and property insurance are examples of fixed costs. While fixed costs may respond to structural and organizational cost drivers over time, they do not respond to short-run changes in activity cost drivers.
3. **Mixed costs** (sometimes called **semivariable costs**) contain a fixed and a variable cost element. Total mixed costs are positive (like fixed costs) when activity is zero, and they increase in a linear

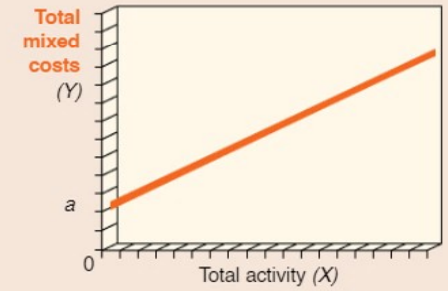
Exhibit 15.1 Cost Behavior Patterns



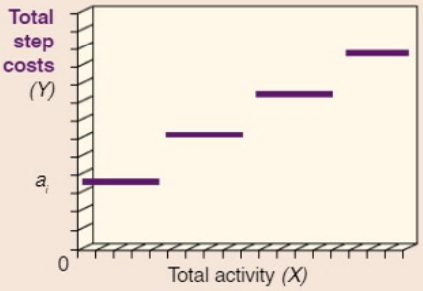
Total variable costs increase in proportion to increases in activity cost drivers.



Total fixed costs do not respond to changes in activity cost drivers within a period or range.



Total mixed costs contain fixed and variable cost elements. They increase but not in direct proportion to increases in activity cost drivers.



Total step costs are constant over a narrow range of cost driver activity but increase in steps as activity increases.

fashion (like total variable costs) as activity increases. With the number of pizzas sold as the cost driver, the cost of electric power is an example of a mixed cost. Some electricity is required to provide basic lighting (fixed cost), while an increasing amount of electricity is required to prepare food as the number of pizzas served increases (variable cost).

4. **Step costs** are constant within a narrow range of activity but shift to a higher level when activity exceeds the range. Total step costs increase in a steplike fashion as activity increases. With the number of pizzas served as the cost driver, employee wages is an example of a step cost. Up to a certain number of pizzas, only a small staff needs to be on duty. Beyond that number, additional employees are needed for quality service and so forth.

The relationship between total cost (*Y* axis) and total activity (*X* axis) for the four cost behavior patterns is mathematically expressed as follows:

$$\text{Variable cost: } Y = bX$$

where

b = the variable cost per unit, sometimes referred to as the slope of the cost function.

$$\text{Fixed cost: } Y = a$$

where

a = total fixed costs. The slope of the fixed cost function is zero because fixed costs do not change with activity.

Mixed cost: $Y = a + bX$

where

a = total fixed cost element

b = variable cost element per unit of activity.

Step cost: $Y = a_i$

where

a_i = the step cost within a specific range of activity, identified by the subscript i.

The total cost function of most organizations has shifted in recent years toward more fixed costs and fewer variable costs, making it increasingly important for organizations to manage their fixed costs. Some organizations have done this by outsourcing activities rather than performing the activities internally. This avoids the many fixed costs of infrastructure in exchange for a variable cost per unit of activity. The Business Insight box below provides a few examples of how understanding costs can lead to better pricing decisions.

Business Insight ■ Understanding Costs Is Key to Pricing

Pricing affects firm performance, and understanding the cost of servicing a customer is the key to effective pricing. Analysts from the Strategy and Operations practice of **Deloitte Consulting** recommend using rich datasets to segment customers based on needs and behavior. Careful segmenting allows the firm to find the most profitable match of customers with services and prices.

The auto insurance industry is an interesting case. The cost of service is driven by the risk of a claim. Traditionally, auto insurers collect a list of risk factors when calculating the cost of insuring a particular driver. This list includes factors such as age, gender, address, and sometimes an estimate of expected mileage. Under this system, a young driver with fewer estimated annual miles often receives a higher rate than a more experienced driver with more estimated annual miles. Unfortunately for traditional insurers, up to 70% of the variation in risk is due to the actual number of miles driven; so young, low-mile drivers subsidize more experienced drivers.

A new trend in auto insurance is to gather detailed mileage data and charge drivers a low monthly premium with a variable mileage charge. A pioneer of this approach, **Metromile**, uses a smartphone app and a thumbnail-sized device that users install in their vehicles to gather usage data. Gathering better data on mileage allows Metromile to offer substantially lower rates to drivers simply by better estimating the cost of insuring each customer.

Sources: Quentin Hardy, "Technology Transforms How Insurers Calculate Risk," *The New York Times*, April 6, 2016.
John Hagel, John Brown, Maggie Wooll, and Andrew de Maar, "Align Price With Use," *Deloitte University Press*, February 12, 2016.
Julie Meehan, Chuck Davenport, and Shruti R. Kahlon, "The Price of Pricing Effectiveness: Is the View Worth the Climb?" *Deloitte University Press*, July 1, 2012.

Factors Affecting Cost Behavior Patterns

The four cost behavior patterns presented are based on the fundamental assumption that a unit of final output is the primary cost driver. The implications of this assumption are examined later in this module.

Another important assumption is that the time period is too short to incorporate changes in strategic cost drivers such as the scale of operations. Although this assumption is useful for short-range planning, for the purpose of developing plans for extended time periods, it is more appropriate to consider possible variations in one or more strategic cost drivers. When this is done, many costs otherwise classified as fixed are better classified as variable.

Even the cost of depreciable assets can be viewed as variable if the time period is long enough. Assuming that the number of pizzas served is the cost driver, for a single month the depreciation on all Papa Murphy's restaurants in the world is a fixed cost. Over several years, if sales are strong, a strategic decision will be made to open additional restaurants; if sales are weak, strategic decisions will likely be made to close some restaurants. Hence, over a multiple-year period, the number of restaurants varies with sales volume, making depreciation appear as a variable cost with sales revenue as the cost driver.

Fixed costs are easily identified. They are the same at each activity level. Variable and mixed costs can be determined by dividing total costs by monthly sales at two activity levels. The quotients of

variable costs will be the same at both levels. The quotients of mixed costs will be lower at the higher

variable costs will be the same at both levels. The quotients of mixed costs will be lower at the higher activity level. This is because the fixed costs are spread over a larger number of units.

LO1 **Review 15-1**

Assume a local **Subway** reported the following results for April and May:

	April	May
Sandwiches sold	2,100	2,700
Cost of food sold	$1,575	$2,025
Wages and salaries	1,525	1,675
Rent on building	1,500	1,500
Depreciation on equipment	200	200
Utilities	710	770
Supplies	225	255
Miscellaneous	113	131
Total	$5,848	$6,556

Required

Identify each cost as being fixed, variable, or mixed.

Solution on p. 15-33.

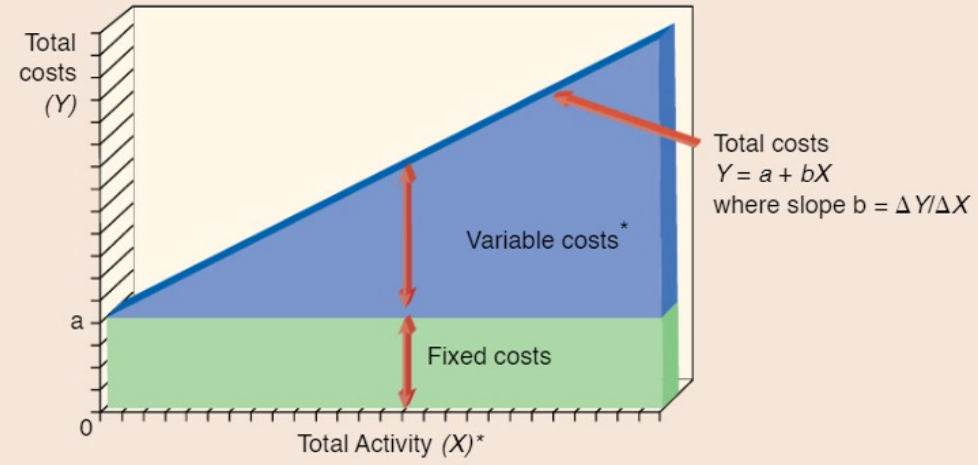
Total Cost Function for an Organization or Segment

eLectures MBC **LO2** Determine a linear total cost estimating equation.

To obtain a general understanding of an organization, to compare the cost structures of different organizations, or to perform preliminary planning activities, managers are often interested in how total costs respond to a single measure of overall activity such as units sold or sales revenue. This overview can be useful, but presenting all costs as a function of a single cost driver is seldom accurate enough to support decisions concerning products, services, or activities. Doing so implies that all of an organization's costs can be manipulated by changing a single cost driver. This is seldom true.

In developing a total cost function, the independent variable usually represents some measure of the goods or services provided customers, such as total student credit hours in a university, total sales revenue in a store, total guest-days in a hotel, or total units manufactured in a factory. The resulting cost function is illustrated in Exhibit 15.2.

Exhibit 15.2 Total Cost Behavior



*Variable costs are layered on top of fixed costs.

The equation for total costs is:

The equation for total costs is:

$$Y = a + bX$$

where

Y = total costs
a = vertical axis intercept (an approximation of fixed costs)
b = slope (an approximation of variable costs per unit of X)
X = value of independent variable

In situations where the variable, fixed, and mixed costs, and the related cost functions, can be determined, a total cost equation can be useful in predicting future costs for various activity levels. For example, assume that **Coco Froyo** frozen yogurt shop's only fixed cost is the depreciation on its frozen yogurt making machines. Coco Froyo's monthly depreciation is $1,200. Also assume that the variable cost per frozen yogurt served is $3.25. Therefore, the total cost equation for Coco Froyo is:

Y = $1,200 + $3.25 (number of yogurts served)

If the shop expects to serve 1,600 frozen yogurts in July, they can then estimate their total July costs to be:

$6,400 = $1,200 + $3.25 (1,600)

Relevant Range

Generally, a total cost equation is useful for predicting costs in only a limited range of activity. The **relevant range** of a total cost equation is that portion of the range associated with the fixed cost of the current or expected capacity. In our Coco Froyo example, they are able to produce a maximum of 50 gallons of frozen yogurt per day with a single machine. If it has four machines in operation, and if it can readily adjust its fixed capacity cost by increasing or decreasing the number of machines, the relevant range of activity for the shop's current total cost equation is 151 to 200 gallons. In the future, if the shop expects to operate at more than 200 gallons per day, the current total cost equation would not predict total cost accurately, because fixed costs would have to be increased for additional machines. Conversely, if it expects to operate at 150 gallons or fewer, it may reduce the number of machines in the shop, thereby reducing total fixed costs.

The use of straight lines in accounting models of cost behavior assumes a linear relationship between cost and activity with each additional unit of activity accompanied by a uniform increment in total cost. This uniform increment is known as the *variable cost of one unit*.

Economic models show a nonlinear relationship between cost and activity with each incremental unit of activity being accompanied by a varying increment in total cost. Economists identify the varying increment in total cost as the **marginal cost** *of one unit*. For our Coco Froyo example, the marginal cost of one unit is specifically the additional costs incurred with each additional serving of yogurt sold.

It is useful to relate marginal costs to the following three levels of activity:

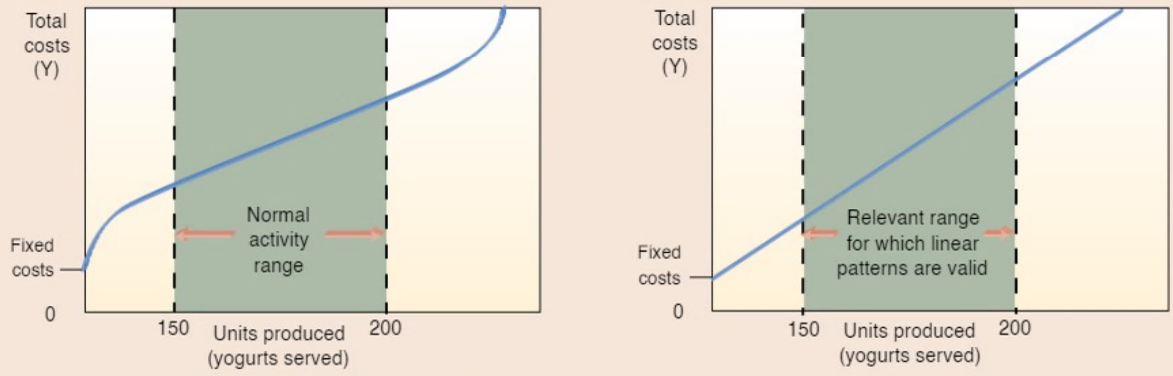
1. *Below the activity range for which the facility was designed,* the existence of excess capacity results in relatively high marginal costs. Having extra time, employees complete assignments at a leisurely pace, increasing the time and the cost to produce each unit above what it would be if employees were more pressed to complete work. Frequent starting and stopping of equipment may also add to costs. For Coco Froyo this would be operating at a level of 150 gallons per day or fewer.
2. *Within the activity range for which the facility was designed,* activities take place under optimal circumstances and marginal costs are relatively low. For Coco Froyo this would be operating within a range of 151 to 200 gallons per day.
3. *Above the activity range for which the facility was designed,* the existence of capacity constraints again results in relatively high marginal costs. Near capacity, employees may be paid overtime

wages, less experienced employees may be used, regular equipment may operate less efficiently

wages, less-experienced employees may be used, regular equipment may operate less efficiently, and old equipment with high energy requirements may be placed in service. For Coco Froyo this would be operating at a level of more than 200 gallons per day.

Based on marginal cost concepts, the economists' short-run total cost function is illustrated in the first graph in Exhibit 15.3. To clarify the concept, we use the capacity information for Coco Froyo. The vertical axis intercept represents capacity costs. In this simple example, our only capacity, or fixed cost, is depreciation. Corresponding to the high marginal costs at low levels of activity, the initial slope is quite steep. In the normal activity range, where marginal costs are relatively low, the slope becomes less steep. Then, corresponding to high marginal costs above the normal activity range, the slope of the economists' total cost function increases again.

Exhibit 15.3 Economic and Accounting Total Cost Structures



Business Insight Firm Makes Warehouse Costs Variable

A warehouse is an essential but risky investment for many businesses. The risk is that actual activity will be above or below the level for which the facility was designed. The **Raj India Trading Co.**, a Seattle-area importer, found itself in just this situation when changes to their product lines left them with a vastly underused warehouse. Rather than find a new, smaller warehouse, owner Jeff Lykins used the services of Flexe Inc. to rent out the unused space on a month-to-month basis.

While industrial real estate vacancy is low (around 5% in key areas such as Seattle and Southern California), experts agree that there is a surplus of warehouse space. **Flexe Inc.** has carved out a niche by connecting companies in need of warehouse space and companies with unused space. Flexe lets those who need more space rent it by the pallet and helps those with too much space integrate the new pallets into their existing workflow. Flexe helps companies with fixed warehouse costs maintain usage and consume excess capacity.

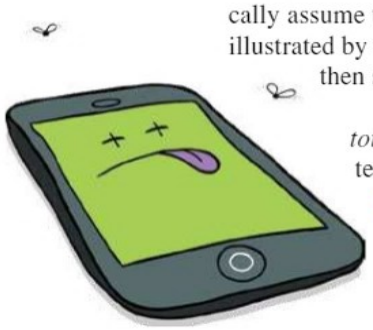
Sources: David Morris, "This Startup Could Change the Game for Same-day Shipping," *Fortune*, October 9, 2015.
Erica E. Phillips, "Collaborative Logistics Comes to the Warehouse," *The Wall Street Journal*, June 12, 2015.

If the economists' total cost curve is valid, how can we reasonably approximate it with a straight line? The answer to this question is in the notion of a *relevant range*. A linear pattern may be a poor approximation of the economists' curvilinear pattern over the entire range of possible activity, but a linear pattern as illustrated in the right-hand graph in Exhibit 15.3 is often sufficiently accurate within the range of probable operations. The range of activity within which a linear cost function is valid is called the relevant range. Linear estimates of cost behavior are valid only within the relevant range. Extreme care must be exercised when making comments about cost behavior outside the relevant range.

Additional Cost Behavior Patterns

Additional Cost Behavior Patterns

Although we have considered the most frequently used cost behavior patterns, remember that there are numerous ways that costs can respond to changes in activity. Avoid the temptation to automatically assume that the cost in question conforms to one of the patterns discussed in this module. As illustrated by the preceding Business Insight box, it is important to think through each situation and then select a behavior pattern that seems logical and fits the known facts.



Particular care needs to be taken with the vertical axis. So far, all graphs have placed *total* costs on the vertical axis. Miscommunication is likely if one party is thinking in terms of *total* costs while the other is thinking in terms of *variable* or *average* costs. **FIXthat4U** is a smartphone and tablet repair store. FIXthat4U's monthly fixed costs include rent and depreciation on tools and furniture. Its variable costs include direct labor and any materials used up in the repair such as new screens. Consider FIXthat4U's following cost function:

Total costs = $3,000 □ $5X

where

X = customer repairs

The total, variable cost per unit, and average cost per unit at various levels of activity are computed here and graphed in Exhibit 15.4 on the following page. As the number of customer repairs increases, total costs increase, the variable costs of each repair remain constant, and the average cost decreases because fixed costs are spread over a larger number of repairs.

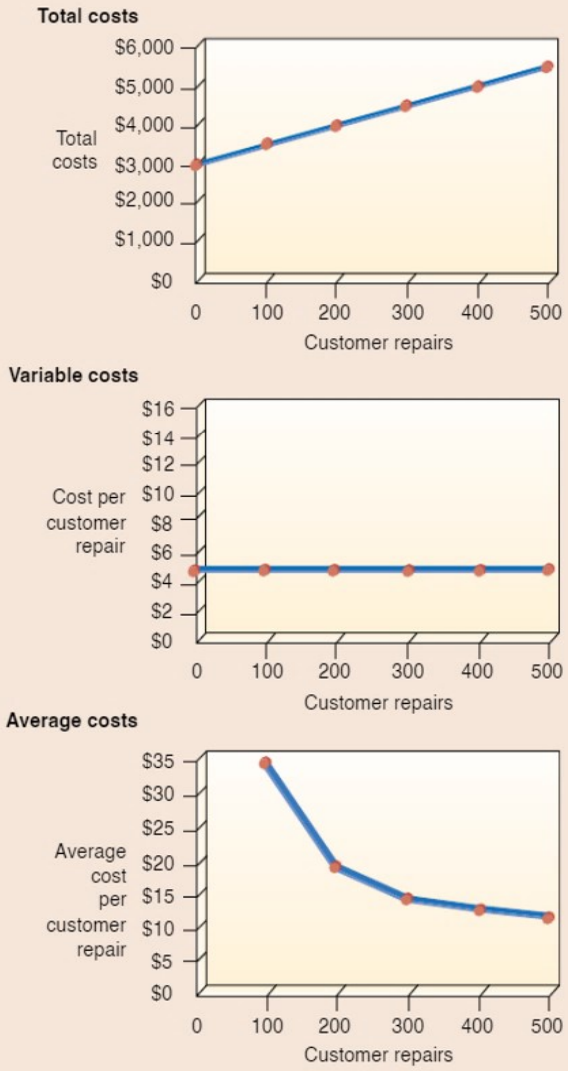
Customer Repairs	Total Costs	Average Cost*	Variable Costs per Repair
100	$3,500	$35.00	$5.00
200	4,000	20.00	5.00
300	4,500	15.00	5.00
400	5,000	12.50	5.00
500	5,500	11.00	5.00

* Total costs/customer repairs

To predict total costs for the coming period, FIXthat4U's management will use the first graph in Exhibit 15.4. To determine the minimum price required to avoid a loss on each additional repair, management is interested in the variable costs per customer repair, yet if a manager inquired as to the cost of each customer repair, a financial accountant would probably provide average cost information, as illustrated in the third graph in Exhibit 15.4. The specific average cost would likely be a function of the number of customer repairs during the most recent accounting period.

Errors can occur if last period's average costs, perhaps based on a volume of 500 repairs, were used to predict total costs for a future period when the anticipated volume was some other amount, say 300 repairs. Using average costs, based on the 500 repairs, the predicted total costs of 300 repairs are $3,300 ($11 × 300). In fact, using the proper total cost function, a more accurate prediction of total costs is $4,500 [$3,000 + ($5 × 300)]. The prediction error could cause a number of problems. If management budgeted $3,300 to pay bills and the bills actually totaled $4,500, the company might have to curtail activities or borrow under unfavorable terms to avoid running out of cash.

Exhibit 15.4 Total Costs, Variable Costs, and Average Costs



Research Insight ■ Managers Use Procurement to Control Risk

In a recent study of cost data from California Hospitals, researchers analyzed the way that firms adjust committed costs in response to external risk. The study shows that managers seek to mitigate the effects of both demand uncertainty and financial risk through procurement decisions. The study considers three procurement choices that affect committed costs:

1. Deliver new services through outsourcing or onsite.
2. Rent or purchase new equipment.
3. Structure labor costs to be more flexible versus fixed.

The researchers found that hospitals facing greater uncertainty limited committed costs, for example, limiting capital expenditures on equipment. This study highlights that managers can make cost-structure decisions that protect their organizations from the risk of demand uncertainty.

Source: Martin Holzhacker, Ranjani Krishnan, and Matthias D. Mahlendorf, "Unraveling the Black Box of Cost Behavior: An Empirical Investigation of Risk Drivers, Managerial Resource Procurement, and Cost Elasticity," *The Accounting Review* 90, no. 6 (2015): 2305-2335.

Committed and Discretionary Fixed Costs

Committed and Discretionary Fixed Costs

Fixed costs are often classified as *committed* or *discretionary*, depending on their immediate impact on the organization if management attempts to change them. **Committed fixed costs**, sometimes referred to as **capacity costs**, are the fixed costs required to maintain the current service or production capacity or to fill previous legal commitments. Examples of committed fixed costs include depreciation, property taxes, rent, and interest on bonds.

Committed fixed costs are often the result of structural decisions about the size and nature of an organization. For example, years ago the management of **Santa Fe Railroad** made decisions concerning what communities the railroad would serve. Track was laid on the basis of those decisions, and the Santa Fe Railroad now pays property taxes each year on the railroad's miles of track. These property taxes could be reduced by disposing of track. However, reducing track would also diminish the Santa Fe's capacity to serve.

Discretionary fixed costs, sometimes called **managed fixed costs**, are set at a fixed amount each period at the discretion of management. It is possible to reduce discretionary fixed costs without reducing production or service capacity in the short term. Typical discretionary fixed costs include advertising, maintenance, charitable contributions, employee training, and research and development.

Maintenance expenditures for discretionary fixed costs are frequently regarded as investments in the future. Research and development, for example, is undertaken to develop new or improved products that can be profitably produced and sold in future periods. During periods of financial well-being, organizations may make large expenditures on discretionary cost items. Conversely, during periods of financial stress, organizations likely reduce discretionary expenditures before reducing capacity costs. Unfortunately, fluctuations in the funding of discretionary fixed costs may reduce the effectiveness of long-range programs. A high-quality research staff may be difficult to reassemble if key personnel are laid off. Even the contemplation of layoffs may reduce the staff's effectiveness. In all periods, discretionary costs are subject to debate and are likely to be changed in the budgeting process.

Review 15-2 LO2

Guided Examples MBC

Identify each of the following cost behavior patterns as variable, committed fixed, discretionary fixed, mixed, or step.

a. Total cost of bakery products used at a **McDonald's** restaurant when the number of meals served is the activity cost driver.
b. Total cost of operating the **Mayo Clinic** when the number of patients served is the cost driver.
c. Total property taxes for a **Midas** auto repair shop when the number of vehicles serviced is the cost driver.
d. Total cost of motherboards used by **Apple** when the number of computers manufactured and shipped is the cost driver.
e. Total cost of secretarial services at **Indiana University** with each secretary handling the needs of ten faculty members and where part-time secretarial help is not available. The number of faculty is the cost driver.
f. Total advertising costs for **International Business Machines** (IBM).
g. Automobile rental costs incurred by **Alamo** in Orlando, Florida, when there is no mileage charge. The cost driver is the number of miles driven.
h. Automobile rental cost incurred by **Hertz** in Dallas, Texas, which has a base charge plus a mileage charge. The cost driver is the number of miles driven.
i. Salaries paid to personnel while conducting on-campus employment interviews for **Champion International**. Number of on-campus interviews is the cost driver.
j. The cost of contributions to educational institutions by **Microsoft Corporation**.

Solution on p. 15-33.

Cost Estimation

eLectures MBC **LO3** Calculate and compare three different approaches to cost estimation.

Cost estimation, the determination of the relationship between activity and cost, is an important part of cost management. In this section, we develop equations for the relationship between total costs and total activity.

To properly estimate the relationship between activity and cost, we must be familiar with basic cost behavior patterns and cost estimating techniques. Costs known to have a variable or a fixed

pattern are readily estimated by interviews or by analyzing available records. Sales commission per

pattern are readily estimated by interviews or by analyzing available records. Sales commission per sales dollar, a variable cost, might be determined to be 15 percent of sales. In a similar manner, annual property taxes might be determined by consulting tax documents.

Mixed (semivariable) costs, which contain fixed and variable cost elements, are more difficult to estimate. According to a basic rule of algebra, two equations are needed to determine two unknowns. Following this rule, at least two observations are needed to determine the variable and fixed elements of a mixed cost.

High-Low Cost Estimation

The most straightforward approach to determining the variable and fixed elements of mixed costs is to use the **high-low method of cost estimation**. This method utilizes data from two time periods, a *representative* high-activity period and a *representative* low-activity period, to estimate fixed and variable costs. Assuming identical fixed costs in both periods, any difference in total costs between these two periods is due entirely to variable costs. The variable costs per unit are found by dividing the difference in total costs by the difference in total activity:

$$\text{Variable costs per unit} = \frac{\text{Difference in total costs}}{\text{Difference in activity}}$$

Once variable costs are determined, fixed costs, which are identical in both periods, are computed by subtracting the total variable costs of either the high or the low activity period from the corresponding total costs.

$$\text{Fixed costs} = \text{Total costs} - \text{Variable costs}$$

Assume a retailer such as **Pottery Barn** wants to develop a monthly cost function for its packaging department and that the number of shipments is believed to be the primary cost driver. The following observations are available for the first four months of 2017.

		Number of Shipments	Packaging Costs
(Low-activity period)	January	6,000	$17,000
	February	9,000	26,000
(High-activity period)	March	12,000	32,000
	April	10,000	20,000

Equations for total costs for the packaging department in January and March (the periods of lowest and highest activity) follow:

$$\text{January: } \$17{,}000 = a + b\,(6{,}000 \text{ shipments})$$
$$\text{March: } \$32{,}000 = a + b\,(12{,}000 \text{ shipments})$$

where

a = fixed costs per month
b = variable costs per shipment

Solving for the estimated variable costs per shipment:

$$b = \frac{\text{Difference in total costs}}{\text{Difference in activity}}$$

$$b = \frac{\$32{,}000 - \$17{,}000}{12{,}000 - 6{,}000}$$

$$= \$2.50$$

Next, the estimated monthly fixed costs are determined by subtracting variable costs from total costs

Next, the estimated monthly fixed costs are determined by subtracting variable costs from total costs of *either* the January or March equation:

$$\text{a} = \text{Total costs} - \text{Variable costs}$$

$$\text{January: a} = \$17{,}000 - (\$2.50 \text{ per shipment} \times 6{,}000 \text{ shipments})$$

$$= \$2{,}000$$

or

$$\text{March: a} = \$32{,}000 - (\$2.50 \text{ per shipment} \times 12{,}000 \text{ shipments})$$

$$= \$2{,}000$$

The cost estimating equation for total packaging department costs is

$$Y = \$2{,}000 + \$2.50X$$

where

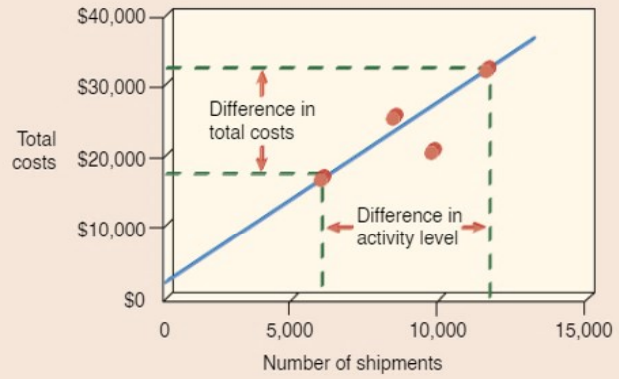
X = number of shipments

Y = total costs for the packaging department

The concepts underlying the high-low method of cost estimation are illustrated in Exhibit 15.5.

Cost prediction, the forecasting of future costs, is a common purpose of cost estimation. Previously developed estimates of cost behavior are often the starting point in predicting future costs. Continuing the Pottery Barn example, if 5,000 shipments are budgeted for June 2017, the predicted June 2017 packaging department costs are $14,500 [$2,000 + ($2.50 per shipment × 5,000 shipments)].

Exhibit 15.5 High-Low Cost Estimation



$$\text{Variable costs per unit} = \frac{\text{Difference in total costs}}{\text{Difference in activity}}$$

$$\text{Fixed costs} = \text{Total costs at either the high or low cost activity level} - \text{Variable costs computed for that level}$$

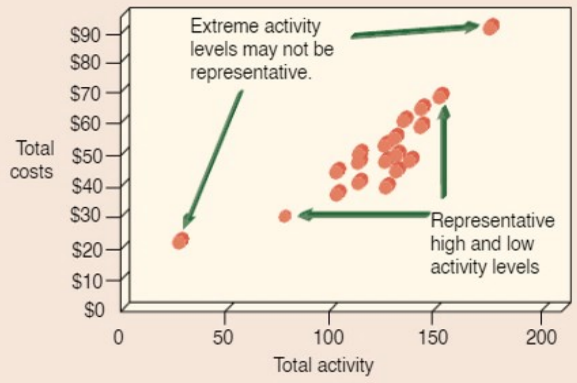
Scatter Diagrams

A **scatter diagram** is a graph of past activity and cost data, with individual observations represented by dots. Plotting historical cost data on a scatter diagram is a useful approach to cost estimation, especially when used in conjunction with other cost-estimating techniques. As illustrated in Exhibit 15.6, a scatter diagram helps in selecting high and low activity levels representative of normal operating conditions. The periods of highest or lowest activity may not be representative because of the cost of overtime, the use of less efficient equipment, strikes, and so forth. If the goal is to develop an equation to predict costs under normal operating conditions, then the equation should be based on observations

of normal operating conditions. A scatter diagram is also useful in determining whether costs can be

of normal operating conditions. A scatter diagram is also useful in determining whether costs can be reasonably approximated by a straight line.

Exhibit 15.6 Selecting High and Low Activity Levels with a Scatter Diagram

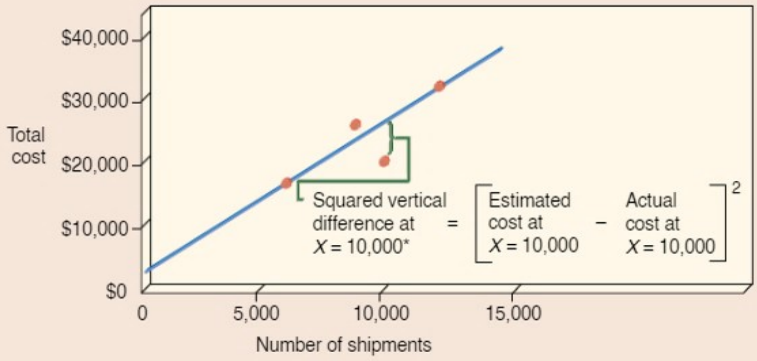


Scatter diagrams are sometimes used alone as a basis of cost estimation. This requires the use of professional judgment to draw a representative straight line through the plot of historical data. Typically, the analyst tries to ensure that an equal number of observations are on either side of the line while minimizing the total vertical differences between the line and actual cost observations at each value of the independent variable. Once a line is drawn, cost estimates at any representative volume are made by studying the line. Alternatively, an equation for the line may be developed by applying the high-low method to any two points on the line.

Least-Squares Regression

Least-squares regression analysis uses a mathematical technique to fit a cost-estimating equation to the observed data. The technique mathematically accomplishes what the analyst does visually with a scatter diagram. The least-squares technique creates an equation that minimizes the sum of the vertical squared differences between the estimated and the actual costs at each observation. Each of these differences is an estimating error. Using the packaging department example, the least-squares criterion is illustrated in Exhibit 15.7. Estimated values of total monthly packaging costs are represented by the straight line, and the actual values of total monthly packaging costs are represented by the dots. For each dot, such as the one at a volume of 10,000 shipments, the line is fit to minimize the vertical squared differences.

Exhibit 15.7 Least-Squares Criterion



*The squared deviation of a single observation is shown; the least-squares technique minimizes the sum of all squared vertical deviations between individual observations and the cost-estimating line.

Values of a and b can be manually calculated using a set of equations developed by mathematicians

Values of *a* and *b* can be manually calculated using a set of equations developed by mathematicians or by using spreadsheet software packages such as Microsoft Excel®. Many calculators also have built-in functions to compute these coefficients. The least-squares equation for monthly packaging costs is:

$$Y = \$3{,}400 + \$2.20X$$

Using the least-squares equation, the predicted June 2017 packaging department costs with 5,000 budgeted shipments are $14,400 [$3,400 + ($2.20 per shipment × 5,000 shipments)]. Recall that the high-low method predicted June 2017 costs of $14,500. Although this difference is small, we should consider which prediction is more reliable.

Advantage of Least-Squares Regression

Mathematicians regard least-squares regression analysis as superior to both the high-low and the scatter diagram methods. It uses all available data, rather than just two observations, and does not rely on subjective judgment in drawing a line. Statistical measures are also available to determine how well a least-squares equation fits the historical data. These measures are often contained in the output of spreadsheet software packages.

In addition to the vertical axis intercept and the slope, least-squares regression calculates the coefficient of determination. The **coefficient of determination** is a measure of the percent of variation in the dependent variable (such as total packaging department costs) that is explained by variations in the independent variable (such as total shipments). Statisticians often refer to the coefficient of determination as R-squared and represent it as R^2.

The coefficient of determination can have values between zero and one, with values close to zero suggesting that the equation is not very useful and values close to one indicating that the equation explains most of the variation in the dependent variable. When choosing between two cost-estimating equations, the one with the higher coefficient of determination is generally preferred. The coefficient of determination for the packaging department cost estimation equation, determined using least-squares regression analysis, is 0.68. This means that 68 percent of the variation in packaging department costs is explained by the number of shipments.

Managers, Not Models, Are Responsible

Although computers make least-squares regression easy to use, the generated output should not automatically be accepted as correct. Statistics and other mathematical techniques are tools to help managers make decisions. Managers, not mathematical models, are responsible for decisions. Judgment should always be exercised when considering the validity of the least-squares approach, the solution, and the data. If the objective is to predict future costs under normal operating conditions, observations reflecting abnormal operating conditions should be deleted. Also examine the cost behavior pattern to determine whether it is linear. Scatter diagrams assist in both of these judgments. Finally, the results should make sense. When the relationships between total cost and several activity drivers are examined, it is possible to have a high R-squared purely by chance. Even though the relationship has a high R-squared, if it "doesn't make sense" there is probably something wrong.

Simple and Multiple Regression

Least-squares regression analysis is identified as "simple regression analysis" when there is only one independent variable and as "multiple regression analysis" when there are two or more independent variables. The general form for simple regression analysis is:

$$Y = a + bX$$

The general form for multiple regression analysis is:

$$Y = a + \Sigma b_i X_i$$

In this case, the subscript i is a general representation of each independent variable. When there

In this case, the subscript i is a general representation of each independent variable. When there are several independent variables, i is set equal to 1 for the first, 2 for the second, and so forth. The total variable costs of each independent variable is computed as b_iX_i, with b_i representing the variable cost per unit of independent variable X_i. The Greek symbol sigma, Σ, indicates that the costs of all independent variables are summed in determining total variable costs.

As an illustration, assume that **Staples**' costs are expressed as a function of the unit sales of its two products: executive desks and task desks. Assume fixed costs are $18,000 per month and the variable costs are $250 per executive desk and $120 per task desk. The mathematical representation of monthly costs with two variables is:

$$Y = a + b_1X_1 + b_2X_2$$

where

$a = \$18{,}000$
$b_1 = \$250$ per executive desk
$b_2 = \$120$ per task desk
$X_1 =$ unit sales of executive desks
$X_2 =$ unit sales of task desks

During a month if 105 executive desks and 200 task desks are sold, Staples' estimated total costs are:

$$Y = \$18{,}000 + \$250(105) + \$120(200)$$
$$= \$68{,}250$$

In addition to estimating costs, multiple regression analysis can be used to determine the effect of individual product features on the market value of a product or service. The following Research Insight reports on insurance companies that use lifestyle and health behaviors to predict future health issues using a model similar to multiple regression analysis. These predictions are used to motivate changes in behavior that will ultimately improve employee health and reduce costs.

Research Insight ■ Employers and Insurers Partner to Reduce Health Care Costs

Improving employee health reduces sick leave and insurance premiums. Insurance companies are partnering with large employers such as **J.P. Morgan Chase** and **WalMart** to use data to reduce health care costs and to help employees improve their health. Some of these opportunities are as simple as using an app to provide information about in-network providers for employees. **Cigna** and **J.P. Morgan Chase** have shifted 2% of claims into network by making a smartphone app with provider information available to employees.

Other solutions use lifestyle and health data to identify at-risk employees and implement lifestyle changes and treatments that reduce the need for expensive procedures and sick leave. **Castlight Healthcare Inc.** uses health data, which the employer is not permitted to see directly, to identify employees who are prediabetic or suffering from back pain. These two conditions have high health care costs, so Castlight sends personalized messages and recommendations for lifestyle changes. Research suggests that 30% of patients considering spinal surgery who get a second opinion elect not to have the surgery. Because spinal surgery is an invasive and costly procedure with a long recovery, Castlight sends personalized recommendations for second opinions to employees who have met with specialists. Another firm, **HealthMine Inc.**, analyzes health records to identify prediabetic employees and provide targeted recommendations for diet and exercise changes.

While issues of privacy around health data are complex, employers and insurers are finding ways to use data to improve employee health and reduce costs.

Source: Rachel Silverman, "Bosses Tap Outside Firms to Predict Which Workers Might Get Sick," *The Wall Street Journal*, February 17, 2016.

Managerial Decision ■ **You are the Purchasing Manager**

Your department has been experiencing increased activity in recent periods as the company has grown, and you have observed that the average cost per purchase order processed has been declining, but not at a constant rate. You have been given an estimate by the production manager of the number of purchase orders that will be processed next period and have been asked by the accounting department to provide within one hour an estimate of the cost to process those orders. How can the scatter diagram method help you to meet this deadline? [Answer, p. 15-22]

Review 15-3 LO3

GuidedExamples MBC

Assume a local **Subway** reported the following results for April and May:

	April	May
Sandwiches sold	2,100	2,700
Cost of food sold	$1,575	$2,025
Wages and salaries	1,525	1,675
Rent on building	1,500	1,500
Depreciation on equipment	200	200
Utilities	710	770
Supplies	225	255
Miscellaneous	113	131
Total	$5,848	$6,556

Required

a. Using the high-low method, create an equation for each of the following costs in April: cost of food, wages and salaries, rent on building, and total monthly costs.

b. Predict total costs for monthly volumes of 1,000 and 2,000 sandwiches.

c. Predict the average cost per unit at monthly volumes of 1,000 and 2,000 sandwiches. Explain why the average costs differ at these two volumes.

Solution on p. 15-34.

Additional Issues in Cost Estimation

eLectures MBC **LO4** Identify and discuss problems encountered in cost estimation.

We have mentioned several items to be wary of when developing cost estimating equations:

- Data that are not based on normal operating conditions.
- Nonlinear relationships between total costs and activity.
- Obtaining a high R-squared purely by chance.

Additional items of concern include:

- Changes in technology or prices.
- Matching activity and cost within each observation.
- Identifying activity cost drivers.

Changes in Technology and Prices

Changes in technology and prices make cost estimation and prediction difficult. When telecommunications companies changed from using landlines to voice over internet protocol (VOIP) to place long-distance telephone calls, cost estimates based on the use of fiber optic cables were of little or no value in predicting future costs. Care must be taken to make sure that data used in developing cost estimates are based on the existing technology. When this is not possible, professional judgment is required to make appropriate adjustments.

Only data reflecting a single price level should be used in cost estimation and prediction. If prices have remained stable in the past but then uniformly increase by 20 percent, cost-estimating equations based on data from previous periods will not accurately predict future costs. In this case, all that is

required is a 20 percent increase in the prediction. Unfortunately, adjustments for price changes are

required is a 20 percent increase in the prediction. Unfortunately, adjustments for price changes are seldom this simple. The prices of various cost elements are likely to change at different rates and at different times. Furthermore, there are probably several different price levels included in the past data used to develop cost-estimating equations. If data from different price levels are used, an attempt should be made to restate them to a single price level.

Matching Activity and Costs

The development of accurate cost-estimating equations requires the matching of the activity to related costs within each observation. This accuracy is often difficult to achieve because of the time lag between an activity and the recording of the cost of resources consumed by the activity. Current activities usually consume electricity, but the electric bill won't be received and recorded until next month. Driving an automobile requires routine maintenance for items such as lubrication and oil, but the auto can be driven several weeks or even months before the maintenance is required. Consequently, daily, weekly, and perhaps even monthly observations of miles driven and maintenance costs are unlikely to match the costs of oil and lubrication with the cost-driving activity, miles driven.

In general, the shorter the time period, the higher the probability of error in matching costs and activity. The cost analyst must carefully review the database to verify that activity and cost are matched within each observation. If matching problems are found, it may be possible to adjust the data (perhaps by moving the cost of electricity from one observation to another). Under other circumstances, it may be necessary to use longer periods to match costs and activity.

Identifying Activity Cost Drivers

Identifying the appropriate activity cost driver for a particular cost requires judgment and professional experience. In general, the cost driver should have a logical, causal relationship with costs. In many cases, the identity of the most appropriate activity cost driver, such as miles driven for the cost of automobile gasoline, is apparent. In other situations, where different activity cost drivers might be used, scatter diagrams and statistical measures, such as the coefficient of determination, are helpful in selecting the activity cost driver that best explains past variations in cost. When scatter diagrams are used, the analyst can study the dispersion of observations around the cost-estimating line. In general, a small dispersion is preferred. If regression analysis is used, the analyst considers the coefficient of determination. In general, a higher coefficient of determination is preferred. The relationship between the activity cost driver and the cost must seem logical, and the activity data must be available.

LO4 **Review 15-4**

Identify some common activity drivers that might be used to state a volume of activity in a manufacturing operation. What general criterion might be used in choosing a driver?

Solution on p. 15-34.

Alternative Cost Driver Classifications

LO5 Describe and develop alternative classifications for activity cost drivers.

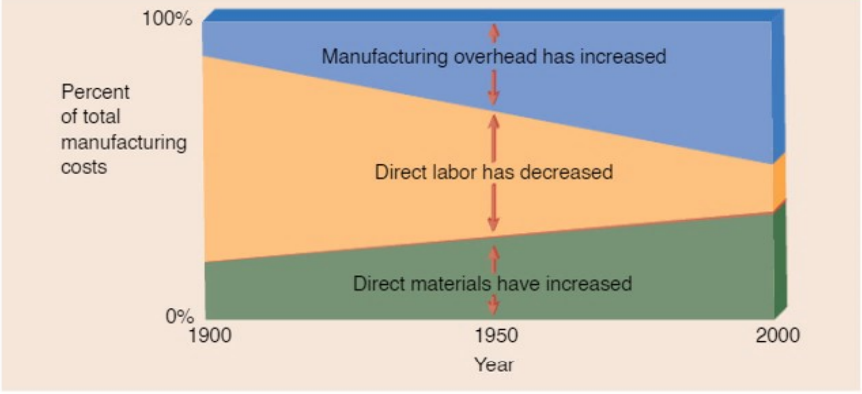
So far we have examined cost behavior and cost estimation using only a unit-level approach, which assumes changes in costs are best explained by changes in the number of units of product or service provided customers. This approach may have worked for **Carnegie Steel Company**, but it is inappropriate for multidimensional organizations, such as **Square**. The unit-level approach becomes increasingly inaccurate for analyzing cost behavior when organizations experience the following types of changes:

- From face-to-face customer interactions to web-based interface,
- From stand-alone products to products with multiple layers of customer interface, such as Square's hardware versus the processing of payments executed by Square for its customers, and
- From internet-based operations to mobile platforms, thus engaging a more geographically diverse set of customers.

Exhibit 15.8 illustrates the composition of total manufacturing costs for the past century, illustrat

Exhibit 15.8 illustrates the composition of total manufacturing costs for the past century, illustrating changes in the percentage of manufacturing costs for three major cost categories.

Exhibit 15.8 Changing Composition of Total Manufacturing Costs



1. **Direct materials**, the cost of primary raw materials converted into finished goods, have increased slightly as organizations purchase components they formerly fabricated. The word "direct" is used to indicate costs that are easily or directly traced to a finished product or service.
2. **Direct labor**, the wages earned by production employees for the time they spend converting raw materials into finished products, has decreased significantly as employees spend less time physically working on products and more time supporting automated production activities.
3. **Manufacturing overhead**, which includes all manufacturing costs other than direct materials and direct labor, has increased significantly due to automation, product diversity, and product complexity.

Changes in the composition of manufacturing costs have implications for the behavior of total costs and the responsiveness of costs to changes in cost drivers. Because direct materials and direct labor vary directly with the number of units, they are easy to measure. In the past, when manufacturing overhead was relatively small, it was possible to assume units of product or service was the primary cost driver. This is no longer true. Units of final product is no longer an adequate explanation of changes in manufacturing overhead for many organizations.

The past tendency to ignore overhead, while focusing on direct materials and direct labor, led one researcher to describe overhead-causing activities as "the hidden factory."[1] To better understand the hidden factory, several researchers have developed frameworks for categorizing cost-driving activities. The crucial feature of these frameworks is the inclusion of nonunit cost drivers. Depending on the characteristics of a particular organization, as well as management's information needs, there are an almost unlimited number of cost driver classification schemes. We consider two frequently applied cost driver classification schemes: one based on a manufacturing cost hierarchy and a second based on a customer cost hierarchy. We also illustrate variations of each.

Manufacturing Cost Hierarchy

The most well-known framework, developed by Cooper[2] and Cooper and Kaplan[3] for manufacturing situations, classifies activities into the following four categories.

1. A **unit-level activity** is performed *for each unit* of product produced. **Christofle** is a French manufacturer of high-end silver flatware. In the production of forks, the stamping of each fork into the prescribed shape is an example of a unit-level cost driver.

[1] Jeffrey G. Miller and Thomas E. Vollmann, "The Hidden Factory," *Harvard Business Review,* September-October 1985, pp. 142–150.

[2] Robin Cooper, "Cost Classification in Unit-Based and Activity-Based Manufacturing Cost Systems," *The Journal of Cost Management,* Fall 1990, pp. 4–14.

[3] Robin Cooper and Robert S. Kaplan, "Profit Priorities from Activity-Based Costing," *Harvard Business Review,* May-June 1991, pp. 130–135.

2. A **batch-level activity** is performed *for each batch* of product produced. At Christofle, a batch

2. A **batch-level activity** is performed *for each batch* of product produced. At Christofle, a batch is a number of identical units (such as a fork of a specific design) produced at the same time. Batch-level activities include setting up the machines to stamp each fork in an identical manner, moving the entire batch between workstations (i.e., molding, stamping, and finishing), and inspecting the first unit in the batch to verify that the machines are set up correctly.
3. A **product-level activity** is performed *to support* the production of *each different type of product*. At Christofle, product-level activities for a specific pattern of fork include initially designing the fork, producing and maintaining the mold for the fork, and determining manufacturing operations for the fork.
4. A **facility-level activity** is performed *to maintain* general manufacturing capabilities. At Christofle, facility-level activities include plant management, building maintenance, property taxes, and electricity required to sustain the building.

Several additional examples of the costs driven by activities at each level are presented in Exhibit 15.9.

Exhibit 15.9 Hierarchy of Activity Costs

Activity Level	Reason for Activity	Examples of Activity Cost
1. Unit level	Performed for each unit of product produced or sold	• Cost of raw materials • Cost of inserting a component • Utilities cost of operating equipment • Some costs of packaging • Sales commissions
2. Batch level	Performed for each batch of product produced or sold	• Cost of processing sales order • Cost of issuing and tracking work order • Cost of equipment setup • Cost of moving batch between workstations • Cost of inspection (assuming same number of units inspected in each batch)
3. Product level	Performed to support each different product that can be produced	• Cost of product development • Cost of product marketing such as advertising • Cost of specialized equipment • Cost of maintaining specialized equipment
4. Facility level	Performed to maintain general manufacturing capabilities	• Cost of maintaining general facilities such as buildings and grounds • Cost of nonspecialized equipment • Cost of maintaining nonspecialized equipment • Cost of real property taxes • Cost of general advertising • Cost of general administration such as the plant manager's salary

When using a cost hierarchy for analyzing and estimating costs, total costs are broken down into the different cost levels in the hierarchy, and a separate cost driver is determined for each level of cost. For example, using the above hierarchy, the costs that are related to the number of units produced (such as direct materials or direct labor) may have direct labor hours or machines hours as the cost driver; whereas, batch costs may be driven by the number of setups of production machines or the number of times materials are moved from one machine to another. Other costs may be driven by the number of different products produced. Facility-level costs are generally regarded as fixed costs and do not vary unless capacity is increased or decreased.

Customer Cost Hierarchy

The manufacturing hierarchy presented is but one of many possible ways of classifying activities and their costs. Classification schemes should be designed to fit the organization and meet user needs. A merchandising organization or the sales division of a manufacturing organization might use the following hierarchy.

1. **Unit-level activity**: performed for each unit sold

1. **Unit-level activity**: performed for each unit sold.
2. **Order-level activity**: performed for each sales order.
3. **Customer-level activity**: performed to obtain or maintain each customer.
4. **Facility-level activity**: performed to maintain the general manufacturing function.

This classification scheme assists in answering questions concerning the cost of individual orders or individual customers.

If an organization sells to distinct market segments (for profit, not for profit, and government), the cost hierarchy can be modified as follows:

1. Unit-level activity
2. Order-level activity
3. Customer-level activity
4. **Market-segment-level activity**: performed to obtain or maintain operations in a segment.
5. Facility-level activity

The market-segment-level activities and their related costs differ with each market segment. This classification scheme assists in answering questions concerning the profitability of each segment.

Finally, an organization that completes unique projects for different market segments (such as buildings for **IBM** and the **U.S. Department of Defense**) can use the following hierarchy to determine the profitability of each segment:

1. **Project-level activity**: performed to support the completion of each project.
2. Market-segment-level activity
3. Facility-level activity

The possibilities are endless. The important point is that both the cost hierarchy and the costs included in the hierarchy be tailored to meet the specific circumstances of an organization and the interests of management.

Review 15-5 LO5

Customer Cost Hierarchy Consider the pizza chain **Blaze Pizza**. They custom build and cook each pizza to order. Items *a.–f.* represent cost activities a particular store might incur.

1. Pepperoni on the pizza
2. Wood to fuel the fire used to cook the pizzas
3. Insurance on the building
4. The labor hours worked by the employee building and cooking each pizza
5. The sales calls made to local organizations to promote the pizzas for catering special events
6. The number of pizza orders received

Required

Classify each cost activity above, in the most appropriate level of the proposed customer cost hierarchy. Each cost activity may be used more than once.

_____ *a.* Unit-level—performed for each unit sold
_____ *b.* Order-level—performed for each sales level
_____ *c.* Customer-level—performed to obtain or maintain each customer
_____ *d.* Store(facility)-level—performed to maintain the general store functions

Solution on p. 15-34.

Guidance Answers

You are the Purchasing Manager

Pg. 15-17 One of the quickest methods for gaining a general understanding of the relationship between a given cost and its cost driver is to graph the relationship using data from several recent periods. As purchasing manager you could probably quickly obtain information about the amount of the total purchasing department costs and number of purchase orders processed for each of the most recent eight or ten periods. By graphing these data with costs on the vertical axis and number of purchase orders on the horizontal axis, you should be able to visually determine if there is an obvious behavioral pattern (variable, fixed, or mixed). Since costs have been declining as volume has increased, this would suggest that there are some fixed costs, and that they have been declining on a per unit basis as they are spread over an increasing number of purchase orders. Using two representative data points in the scatter diagram, you can plot a cost curve on the graph, and then use the data for those two points to calculate the estimated fixed and variable costs using the high-low cost estimation method. Using these cost estimates, you can predict the total cost for next period. This method may not give you a precise estimate of the cost, but coupled with your subjective estimate of cost based on your experience as manager of the department, it should give you more confidence than merely making a best guess. Hopefully, you will have an opportunity before presenting your budget for the next period to conduct additional analyses using more advanced methods.

Questions

Q15-1. Briefly describe variable, fixed, mixed, and step costs and indicate how the total cost function of each changes as activity increases within a time period.

Q15-2. Why is presenting all costs of an organization as a function of a single independent variable, although useful in obtaining a general understanding of cost behavior, often not accurate enough to make specific decisions concerning products, services, or activities?

Q15-3. Explain the term "relevant range" and why it is important in estimating total costs.

Q15-4. How are variable and fixed costs determined using the high-low method of cost estimation?

Q15-5. Distinguish between cost estimation and cost prediction.

Q15-6. Why is a scatter diagram helpful when used in conjunction with other methods of cost estimation?

Q15-7. Identify two advantages of least-squares regression analysis as a cost estimation technique.

Q15-8. Why is it important to match activity and costs within a single observation? When is this matching problem most likely to exist?

Q15-9. During the past century, how have direct materials, direct labor, and manufacturing overhead changed as a portion of total manufacturing costs? What is the implication of the change in manufacturing overhead for cost estimation?

Q15-10. Distinguish between the unit-, batch-, product-, and facility-level activities of a manufacturing organization.

Mini Exercises

M15-11. Classifying Cost Behavior LO1

Classify the total costs of each of the following as variable, fixed, mixed, or step. Sales volume is the cost driver.

a. Salary of the department manager
b. Memory chips in a computer assembly plant
c. Real estate taxes

d. Salaries of quality inspectors when each inspector can evaluate a maximum of 1,000 units per day

d. Salaries of quality inspectors when each inspector can evaluate a maximum of 1,000 units per day
e. Wages paid to production employees for the time spent working on products
f. Electric power in a factory
g. Raw materials used in production
h. Automobiles rented on the basis of a fixed charge per day plus an additional charge per mile driven
i. Sales commissions
j. Depreciation on office equipment

LO1 **M15-12. Classifying Cost Behavior**

Classify the total costs of each of the following as variable, fixed, mixed, or step.

Homework MBC

a. Straight-line depreciation on a building
b. Maintenance costs at a hospital
c. Rent on a photocopy machine charged as a fixed amount per month plus an additional charge per copy
d. Cost of goods sold in a bookstore
e. Salaries paid to temporary instructors in a college as the number of course sessions varies
f. Lumber used by a house construction company
g. The costs of operating a research department
h. The cost of hiring a dance band for three hours
i. Laser printer paper for a department printer
j. Electric power in a restaurant

LO1, 2, 3 **M15-13. Classifying Cost Behavior**

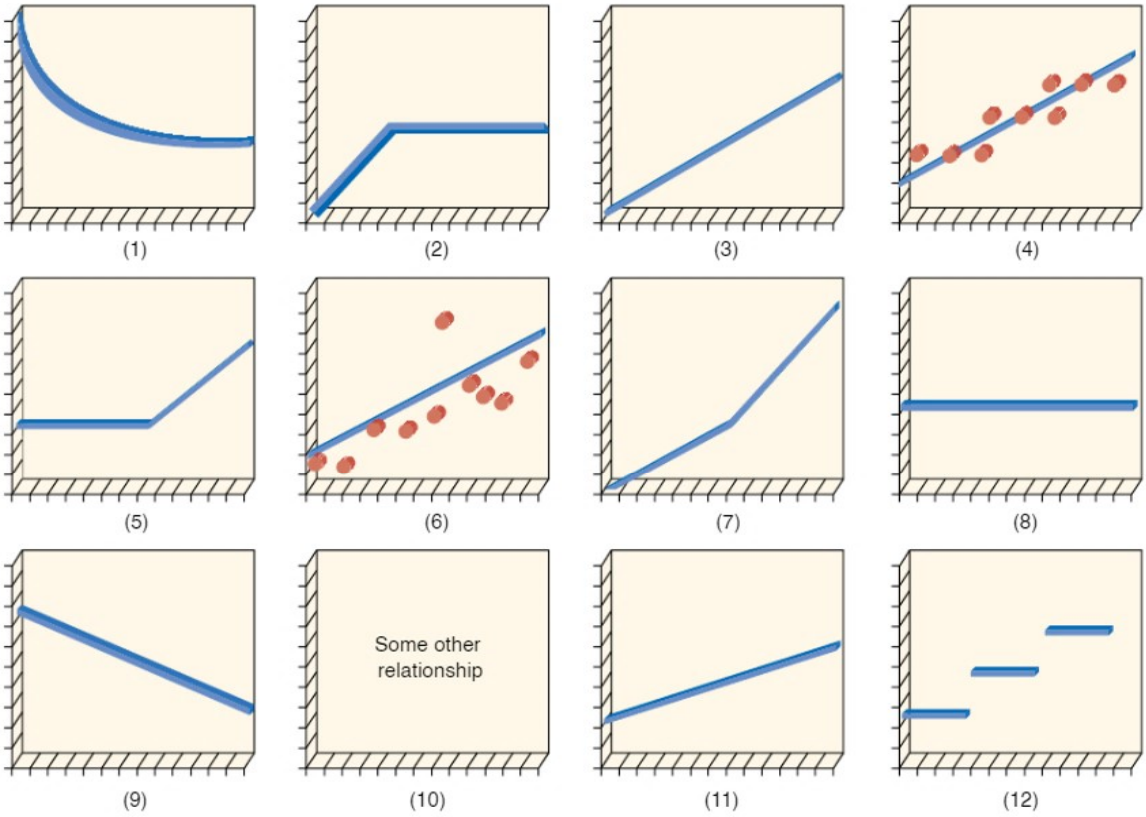
For each of the following situations, select the most appropriate cost behavior pattern (as shown in the illustrations following this problem) where the lines represent the cost behavior pattern, the vertical axis represents costs, the horizontal axis represents total volume, and the dots represent actual costs. Each pattern may be used more than once.

Homework MBC

a. Variable costs per unit
b. Total fixed costs
c. Total mixed costs
d. Average fixed costs per unit
e. Total current manufacturing costs
f. Average variable costs
g. Total costs when employees are paid $15 per hour for the first 40 hours worked each week and $20 for each additional hour
h. Total costs when employees are paid $15 per hour and guaranteed a minimum weekly wage of $300
i. Total costs per day when a consultant is paid $200 per hour with a maximum daily fee of $1,000
j. Total variable costs
k. Total costs for salaries of social workers where each social worker can handle a maximum of 25 cases
l. A water bill where a flat fee of $800 is charged for the first 100,000 gallons and additional water costs $0.005 per gallon
m. Total variable costs properly used to estimate step costs
n. Total materials costs
o. Rent on exhibit space at a convention

Graphs for Mini Exercise 15-13

Graphs for Mini Exercise 15-13



M15-14. Classifying Cost Behavior LO1, 2, 3

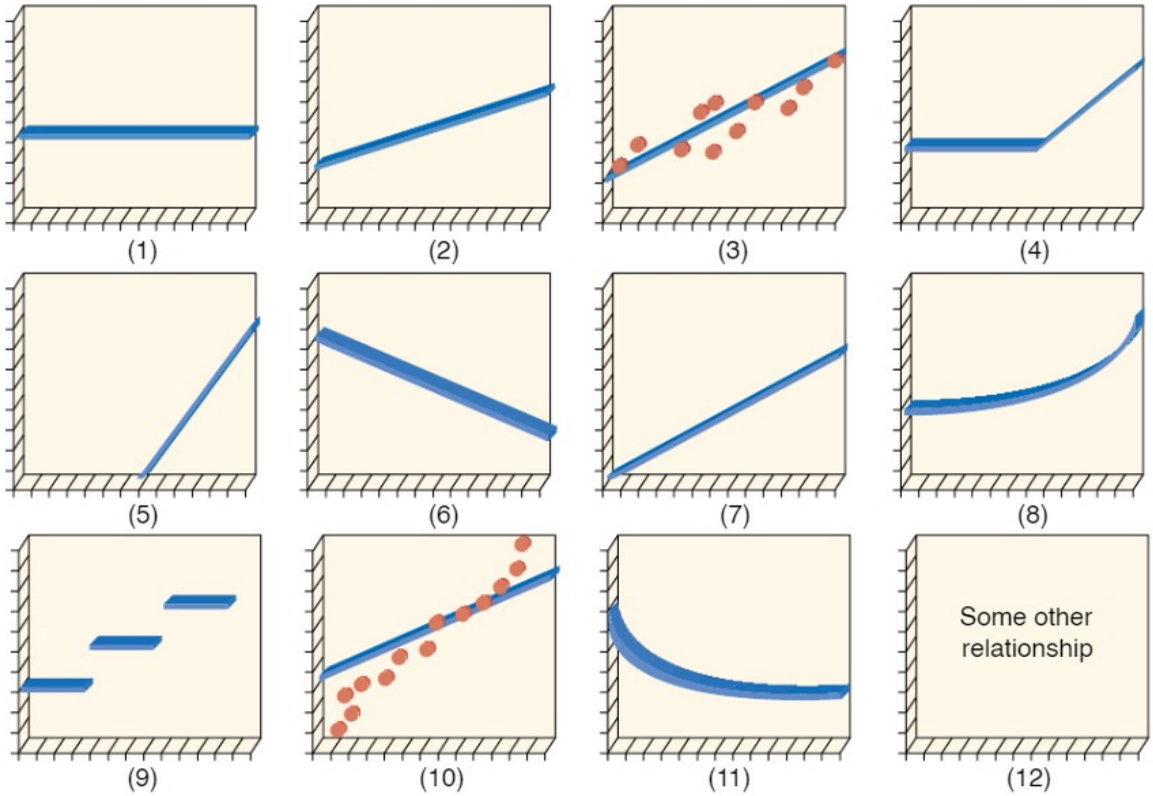
For each of the graphs displayed following this problem, select the most appropriate cost behavior pattern where the lines represent the cost behavior pattern, the vertical axis represents total costs, the horizontal axis represents total volume, and the dots represent actual costs. Each pattern may be used more than once.

Homework MBC

a. A cellular telephone bill when a flat fee is charged for the first 500 minutes of use per month and additional use costs $0.25 per minute
b. Total selling and administrative costs
c. Total labor costs when employees are paid per unit produced
d. Total overtime premium paid production employees
e. Average total cost per unit
f. Salaries of supervisors when each one can supervise a maximum of 10 employees
g. Total idle time costs when employees are paid for a minimum 40-hour week
h. Materials costs per unit
i. Total sales commissions
j. Electric power consumption in a restaurant
k. Total costs when high volumes of production require the use of overtime and obsolete equipment
l. A good linear approximation of actual costs
m. A linear cost estimation valid only within the relevant range

Graphs for Mini Exercise 15-14

Graphs for Mini Exercise 15-14



Exercises

LO2 **E15-15. Computing Average Unit Costs**

The total monthly operating costs of Salads to Go are:

$10,000 □ $0.30X

where

X = Number of salads

Required

a. Determine the average cost per salad at each of the following monthly volumes: 100; 1,000; 5,000; and 10,000.

b. Determine the monthly volume at which the average cost per serving is $0.70.

LO2 **E15-16. Automatic versus Manual Processing**

Image Solutions operates a printing service for customers with digital cameras. The current service, which requires employees to download photos from customer cameras, has monthly operating costs of $7,000 plus $0.3 per photo printed. Management is evaluating the desirability of acquiring a machine that will allow customers to download and make prints without employee assistance. If the machine is acquired, the monthly fixed costs will increase to $13,000 and the variable costs of printing a photo will decline to $0.05 per photo.

Required

a. Determine the total costs of printing 20,000 and 50,000 photos per month:

1. With the current employee-assisted process.
2. With the proposed customer self-service process.

b. Determine the monthly volume at which the proposed process becomes preferable to the current process.

E15-17. Automatic versus Manual Processing **LO2**

E15-17. Automatic versus Manual Processing LO2

Red Star Copy Service processes 2,100,000 photocopies per month at its service center. Approximately 50 percent of the photocopies require collating. Collating is currently performed by high school and college students who are paid $9 per hour. Each student collates an average of 5,000 copies per hour. Management is contemplating the lease of an automatic collating machine that has a monthly capacity of 6,000,000 photocopies, with lease and operating costs totaling $1,550, plus $0.05 per 1,000 units collated.

Required

a. Determine the total costs of collating 500,000 and 1,700,000 per month:
1. With student help.
2. With the collating machine.

b. Determine the monthly volume at which the automatic process becomes preferable to the manual process.

E15-18. High-Low Cost Estimation LO3

YRC Worldwide (YRCW)

Assume the local **YRC Worldwide** delivery service hub has the following information available about fleet miles and operating costs:

Year	Miles	Operating Costs
2017	556,000	$175,600
2018	684,000	214,000

Required

Use the high-low method to develop a cost-estimating equation for total annual operating costs.

E15-19. Scatter Diagrams and High-Low Cost Estimation LO2, 3

Pearle Vision

Assume the local **Pearle Vision** has the following information on the number of sales orders received and order-processing costs.

Month	Sales Orders	Order-Processing Costs
1	3,000	$ 82,700
2	1,500	50,375
3	4,400	120,700
4	2,800	81,900
5	2,300	69,775
6	1,200	43,100
7	2,000	62,500

Required

a. Use information from the high- and low-volume months to develop a cost-estimating equation for monthly order-processing costs.

b. Plot the data on a scatter diagram. Using the information from representative high- and low-volume months, develop a cost-estimating equation for monthly production costs.

c. What factors might have caused the difference in the equations developed for requirements (*a*) and (*b*)?

E15-20. Scatter Diagrams and High-Low Cost Estimation LO2, 3

Coles County

From April 1 through October 31, **Coles County Highway Department** hires temporary employees to mow and clean the right-of-way along county roads. The County Road Commissioner has asked you to help her in determining the variable labor cost of mowing and cleaning a mile of road. The following information is available regarding current-year operations:

Month	Miles Mowed and Cleaned	Labor Costs
April	350	$ 9,600
May	300	8,800
June	400	10,400
July	250	8,000
August	375	10,000
September	200	7,200
October	100	6,200

Required

a. Use the information from the high- and low-volume months to develop a cost-estimating equation for monthly labor costs.

b. Plot the data on a scatter diagram. Using the information from representative high- and low-volume months, use the high-low method to develop a cost-estimating equation for monthly labor costs.

c. What factors might have caused the difference in the equations developed for requirements (*a*) and (*b*)?

d. Adjust the equation developed in requirement (*b*) to incorporate the effect of an anticipated 8 percent increase in wages.

LO2, 3 Potbelly's (PBPB)

E15-21. Cost Behavior Analysis in a Restaurant: High-Low Cost Estimation

Assume a **Potbelly's** restaurant has the following information available regarding costs at representative levels of monthly sales:

Homework MBC

	Monthly sales in units		
	5,000	8,000	10,000
Cost of food sold	$10,000	$16,000	$20,000
Wages and fringe benefits	4,200	4,320	4,400
Fees paid delivery help	1,100	1,760	2,200
Rent on building	1,100	1,100	1,100
Depreciation on equipment	900	900	900
Utilities	800	920	1,000
Supplies (soap, floor wax, etc.)	250	340	400
Administrative costs	1,700	1,700	1,700
Total	$20,050	$27,040	$31,700

Required

a. Identify each cost as being variable, fixed, or mixed.

b. Use the high-low method to develop a schedule identifying the amount of each cost that is mixed or variable per unit. Total the amounts under each category to develop an equation for total monthly costs.

c. Predict total costs for a monthly sales volume of 9,800 units.

LO2, 3

E15-22. Developing an Equation from Average Costs

Paradise Pup is a high-end dog hotel located in New York. Assume that in March, when dog-days occupancy was at an annual low of 500 days, the average cost per dog-day was $26. In July, when dog-days were at a capacity level of 4,500, the average cost per dog-day was $10.

Homework MBC

Required

a. Develop an equation for monthly operating costs.

b. Determine the average cost per dog-day at an annual volume of 28,000 dog-days.

E15-23. Selecting an Independent Variable: Scatter Diagrams LO2, 3

E15-23. Selecting an Independent Variable: Scatter Diagrams LO2, 3

Eclipse Co. produces backpacks that are designed specifically for business executives and managers. The backpacks are sold to department stores throughout the northeast region. Presented is information on production costs and inventory changes for five recent months:

	January	February	March	April	May
Finished goods inventory in units:					
Beginning	30,000	40,000	50,000	30,000	60,000
Manufactured	60,000	90,000	80,000	90,000	100,000
Available	90,000	130,000	130,000	120,000	160,000
Sold	(50,000)	(80,000)	(100,000)	(60,000)	(120,000)
Ending	40,000	50,000	30,000	60,000	40,000
Manufacturing costs	$300,000	$500,000	$450,000	$450,000	$550,000

Required

a. With the aid of scatter diagrams, determine whether units sold or units manufactured is a better predictor of manufacturing costs.

b. Prepare an explanation for your answer to requirement (*a*).

c. Which independent variable, units sold or units manufactured, should be a better predictor of selling costs? Why?

E15-24. Selecting a Basis for Predicting Shipping Expenses (Requires Computer Spreadsheet*) LO2, 3

Boom Company assembles and sells portable speaker systems throughout the midwest. In an effort to improve the planning and control of shipping expenses, management is trying to determine which of three variables—units shipped, weight shipped, or sales value of units shipped—has the closest relationship with shipping expenses. The following information is available:

Month	Units Shipped	Weight Shipped (lbs.)	Sales Value of Units Shipped	Shipping Expenses
May	6,000	9,300	$200,000	$ 8,960
June	10,000	12,000	220,000	12,320
July	8,000	12,150	160,000	10,400
August	14,000	15,000	228,000	16,640
September	12,000	10,500	280,000	13,760
October	9,000	12,000	320,000	13,120

Required

a. With the aid of a spreadsheet program, determine whether units shipped, weight shipped, or sales value of units shipped has the closest relationship with shipping expenses.

b. Using the independent variable that appears to have the closest relationship to shipping expenses, develop a cost-estimating equation for total monthly shipping expenses.

c. Use the equation developed in requirement (*b*) to predict total shipping expenses in a month when 5,000 units, weighing 7,000 lbs., with a total sales value of $114,000 are shipped.

Problems

P15-25. High-Low and Scatter Diagrams with Implications for Regression LO2, 3

Signature Cookies produces and sells gourmet cookies at each of its restaurants. Presented is monthly cost and sales information for one of Signature's restaurants.

* This assignment requires the use of a computer spreadsheet such as Excel® to solve. This assignment assumes previous knowledge of computer spreadsheets.

Month	Sales (Dozens)	Total Costs
January	3,750	$14,400
February	3,000	13,200
March	2,000	10,200
April	750	9,600
May	2,500	10,800
June	2,750	11,700

Required

a. Using the high-low method, develop a cost-estimating equation for total monthly costs.

b. 1. Plot the equation developed in requirement (*a*).

2. Using the same graph, develop a scatter diagram of all observations for the bagel shop. Select representative high and low values and draw a second cost-estimating equation.

c. Which is a better predictor of future costs? Why?

d. If you decided to develop a cost-estimating equation using least-squares regression analysis, should you include all the observations? Why or why not?

e. Mention two reasons that the least-squares regression is superior to the high-low and scatter diagram methods of cost estimation.

LO5 **P15-26. Multiple Cost Drivers**

Lettuce Serve manufactures a variety of specialty salad dressings. Production runs are both high-volume and low-volume activities, depending on customer orders. Presented is Lettuce Serve's 2017 general manufacturing costs (manufacturing overhead) and each cost's related activity cost driver.

Level	Total Cost	Units of Cost Driver
Unit	$500,000	10,000 machine hours
Batch	50,000	500 customer orders
Product	100,000	25 products

Their cranberry vinaigrette dressing required 3,000 machine hours to fill 10 customer orders for a total of 8,000 units.

Required

a. Assuming all manufacturing overhead is estimated and predicted on the basis of machine hours, determine the predicted total overhead costs to produce the 8,000 units of cranberry vinaigrette.

b. Assuming manufacturing overhead is estimated and predicted using separate rates for machine hours, customer orders, and products (a multiple-level cost hierarchy), determine the predicted total overhead costs to produce the 8,000 units of cranberry vinaigrette.

c. Calculate the error in predicting manufacturing overhead using machine hours versus using multiple cost drivers. Indicate whether the use of only machine hours results in overpredicting or underpredicting the costs to produce 8,000 units of cranberry vinaigrette.

d. Determine the error in the prediction of cranberry vinaigrette batch-level costs resulting from the use of only machine hours. Indicate whether the use of only machine hours results in overpredicting or underpredicting the batch-level costs of cranberry vinaigrette.

e. Determine the error in the prediction of cranberry vinaigrette product-level costs resulting from the use of only machine hours. Indicate whether the use of only machine hours results in overpredicting or underpredicting the product-level costs of cranberry vinaigrette.

LO5 **P15-27. Unit- and Batch-Level Cost Drivers**

KC, a fast-food restaurant, serves fried chicken, fried fish, and french fries. The managers have estimated the costs of a batch of fried chicken for KC's all-you-can-eat Friday Fried Fiesta. Each batch must be 50 pieces. The chicken is precut by the chain headquarters and sent to the stores in 10-piece bags. Each bag costs $4. Preparing a batch of 50 pieces of chicken with KC's special coating takes one employee two hours. The current wage rate is $9 per hour. Another cost driver is the cost of putting fresh oil into the fryers. New oil, costing $6.50, is used for each batch.

Required

a. Determine the cost of preparing one batch of 50 pieces.

b. If management projects that it will sell 150 pieces of fried chicken, determine the total batch and unit costs.

c. If management estimates the sales to be 350 pieces, determine the total costs.

d. How much will the batch costs increase if the government raises the minimum wage to $10 per hour?

d. How much will the batch costs increase if the government raises the minimum wage to $10 per hour?
e. If management decided to increase the number of pieces in a batch to 100, determine the cost of preparing 350 pieces. Assume that the batch would take twice as long to prepare, and management wants to replace the oil after 100 pieces are cooked.

P15-28. Optimal Batch Size LO5

This is a continuation of parts *c* and *e* of P15-27.

Required

Should management increase the batch size to 100? Why or why not?

Management Applications

MA15-29. Significance of High R-Squared LO3

Drew Conner had always been suspicious of "newfangled mathematical stuff," and the most recent suggestion of his new assistant merely confirmed his belief that schools are putting a lot of useless junk in students' heads. It seems that after an extensive analysis of historical data, the assistant suggested that the number of pounds of scrap was the best basis for predicting manufacturing overhead. In response to Mr. Conner's rage, the slightly intimidated assistant indicated that of the 35 equations he tried, pounds of scrap had the highest coefficient of determination with manufacturing overhead.

Required

Comment on Conner's reaction. Is it justified? Is it likely that the number of pounds of scrap is a good basis for predicting manufacturing overhead? Is it a feasible basis for predicting manufacturing overhead?

MA15-30. Estimating Machine Repair Costs LO3

In an attempt to determine the best basis for predicting machine repair costs, the production supervisor accumulated daily information on these costs and production over a one-month period. Applying simple regression analysis to the data, she obtained the following estimating equation:

$$Y = \$800 - \$2.60X$$

where

Y = total daily machine repair costs
X = daily production in units

Because of the negative relationship between repair costs and production, she was somewhat skeptical of the results, even though the R-squared was a respectable 0.765.

Required

a. What is the most likely explanation of the negative variable costs?
b. Suggest an alternative procedure for estimating machine repair costs that might prove more useful.

MA15-31. Ethical Problem Uncovered by Cost Estimation LO4 Brunswick

Sounders Management Company owns and provides management services for several shopping centers. After five years with the company, James Heller was recently promoted to the position of manager of **Brunswick**, an 18-store mall on the outskirts of a downtown area. When he accepted the assignment, James was told that he would hold the position for only a couple of years because Brunswick would likely be torn down to make way for a new sports stadium. James was also told that if he did well in this assignment, he would be in line for heading one of the company's new 200-store operations that were currently in the planning stage.

While reviewing Brunswick's financial records for the past few years, James observed that last year's oil consumption was up by 8 percent, even though the number of heating degree days was down by 4 percent. Somewhat curious, James uncovered the following information:

- Brunswick is heated by forced-air oil heat. The furnace is five years old and has been well maintained.
- Fuel oil is kept in four 5,000-gallon underground oil tanks. The oil tanks were installed 25 years ago.
- Replacing the tanks would cost $80,000. If pollution was found, cleanup costs could go as high as $2,000,000, depending on how much oil had leaked into the ground and how far it had spread.
- Replacing the tanks would add more congestion to Brunswick's parking situation.

Required

What should James do? Explain.

LO5 MA15-32. Activity Cost Drivers and Cost Estimation

LO5 **MA15-32. Activity Cost Drivers and Cost Estimation**

Market Street Soup Company produces ten varieties of soup in large vats, several thousand gallons at a time. The soup is distributed to several categories of customers. Some soup is packaged in large containers and sold to college and university food services. Some is packaged in half-gallon or small containers and sold through wholesale distributors to grocery stores. Finally, some is packaged in a variety of individual servings and sold directly to the public from trucks owned and operated by Market Street Soup Company. Management has always assumed that costs fluctuated with the volume of soup, and cost-estimating equations have been based on the following cost function:

Estimated costs = Fixed costs □ Variable costs per gallon × Production in gallons

Lately, however, this equation has not been a very accurate predictor of total costs. At the same time, management has noticed that the volumes and varieties of soup sold through the three distinct distribution channels have fluctuated from month to month.

Required

a. What *relevant* major assumption is inherent in the cost-estimating equation currently used by Market Street Soup Company?

b. Why might Market Street Soup Company wish to develop a cost-estimating equation that recognizes the hierarchy of activity costs? Explain.

c. Develop the general form of a more accurate cost-estimating equation for Market Street Soup Company. Clearly label and explain all elements of the equation, and provide specific examples of costs for each element.

LO3 **MA15-33. Multiple Regression Analysis for a Special Decision (Requires Computer Spreadsheet*)**

Homework MBC

For billing purposes, Galaxy Health Clinic classifies its services into one of four major procedures, X1 through X4. A local business has proposed that Galaxy provide health services to its employees and their families at the following set rates per procedure:

X1	$ 45
X2	90
X3	60
X4	105

Because these rates are significantly below the current rates charged for these services, management has asked for detailed cost information on each procedure. The following information is available for the most recent 12 months.

		Number of Procedures			
Month	Total Cost	X1	X2	X3	X4
1	$11,500	15	50	103	38
2	12,500	19	60	90	45
3	13,500	25	40	70	75
4	9,500	10	45	60	50
5	10,000	34	25	80	40
6	13,500	45	38	105	53
7	12,750	10	55	95	55
8	10,750	8	60	88	40
9	13,000	30	43	62	70
10	11,000	10	45	50	70
11	11,400	10	35	75	65
12	13,250	36	30	100	60

Required

a. Use multiple regression analysis to determine the unit cost of each procedure. How much variation in monthly cost is explained by your cost-estimating equation?

*This assignment requires the use of a computer spreadsheet such as Excel® to solve. This assignment assumes previous knowledge of computer spreadsheets.

b. Evaluate the rates proposed by the local business. Assuming Galaxy has excess capacity and no

b. Evaluate the rates proposed by the local business. Assuming Galaxy has excess capacity and no employees of the local business currently patronize the clinic, what are your recommendations regarding the proposal?

c. Evaluate the rates proposed by the local business. Assuming Galaxy is operating at capacity and would have to turn current customers away if it agrees to provide health services to the local business, what are your recommendations regarding the proposal?

MA15-34. Cost Estimation, Interpretation, and Analysis (Requires Computer Spreadsheet*) LO3

Brady Table Company produces two styles of modern dining room and kitchen tables. Presented is monthly information on production volume and manufacturing costs:

	Total Manufacturing Costs	Total Tables Produced	Dining Room Tables Produced	Kitchen Tables Produced
June 2017	$ 69,975	375	75	300
July	76,332	308	158	150
August	90,945	428	158	270
September	59,615	315	60	255
October	63,180	263	113	150
November	78,863	315	165	150
December	79,527	368	135	233
January 2018	70,988	375	75	300
February	70,853	330	105	225
March	66,713	270	120	150
April	146,700	473	270	203
May	89,900	420	158	263
June	78,065	383	113	270
July	83,070	353	165	188
August	69,335	293	128	165
September	90,653	390	180	210
October	80,562	375	135	240
November	86,400	405	150	255
December	56,475	248	90	158

Required

a. Use the high-low method to develop a cost-estimating equation for total manufacturing costs. Interpret the meaning of the "fixed" costs and comment on the results.

b. Use the chart feature of a spreadsheet to develop a scatter graph of total manufacturing costs and total units produced. Use the graph to identify any unusual observations.

c. Excluding any unusual observations, use the high-low method to develop a cost-estimating equation for total manufacturing costs. Comment on the results, comparing them with the results in requirement (*a*).

d. Use simple regression analysis to develop a cost-estimating equation for total manufacturing costs. What advantages does simple regression analysis have in comparison with the high-low method of cost estimation? Why must analysts carefully evaluate the data used in simple regression analysis?

e. A customer has offered to purchase 50 dining room tables for $220 per table. Management has asked your advice regarding the desirability of accepting the offer. What advice do you have for management? Additional analysis is required.

MA15-35. Simple and Multiple Regression (Requires Computer Spreadsheet*) LO3

Dan Mullen is employed by a mail-order distributor and reconditions used desktop computers, broadband routers, and laser printers. Dan is paid $12 per hour, plus an extra $6 per hour for work in excess of 40 hours per week. The distributor just announced plans to outsource all reconditioning work. Because the distributor is pleased with the quality of Dan's work, he has been asked to enter into a long-term contract to recondition used desktop computers at a rate of $40 per computer, plus all parts. The distributor also offered to provide all necessary equipment at a rate of $200 per month. Dan has

*This assignment requires the use of a computer spreadsheet such as Excel® to solve. This assignment assumes previous knowledge of computer spreadsheets.

been informed that he should plan on reconditioning as many computers as he can handle, up to a

been informed that he should plan on reconditioning as many computers as he can handle, up to a maximum of 20 per week.

Dan has room in his basement to set up a work area, but he is unsure of the economics of accepting the contract, as opposed to working for a local Radio Stuff store at $11 per hour. Data related to the time spent and the number of units of each type of electronic equipment Dan has reconditioned in recent weeks is as follows:

Week	Laser Printers	Broadband Routers	Desktop Computers	Total Units	Total Hours
1	4	5	5	14	40
2	0	7	6	13	42
3	4	3	7	14	40
4	0	2	12	14	46
5	11	6	4	21	48
6	5	8	3	16	44
7	5	8	3	16	44
8	5	6	5	16	43
9	2	6	10	18	53
10	8	4	6	18	46
Total				160	446

Required

Assuming he wants to work an average of 40 hours per week, what should Dan do?

Solutions to Review Problems

Review 15-1—Solution

Fixed costs are easily identified. They are the same at each activity level. Variable and mixed costs are determined by dividing the total costs for an item at two activity levels by the corresponding units of activity. The quotients of the variable cost items will be identical at both activity levels. The quotients of the mixed costs will differ, being lower at the higher activity level because the fixed costs are being spread over a larger number of units.

Cost	April	May	Behavior
Cost of food sold	$1,575/2,100 = 0.750	$2,025/2,700 = 0.750	Variable
Wages and salaries	$1,525/2,100 = 0.726	$1,675/2,700 = 0.620	Mixed
Rent on building	NA	NA	Fixed
Depreciation on equipment	NA	NA	Fixed
Utilities	$710/2,100 = 0.338	$770/2,700 = 0.285	Mixed
Supplies	$225/2,100 = 0.107	$255/2,700 = 0.094	Mixed
Miscellaneous	$113/2,100 = 0.054	$131/2,700 = 0.049	Mixed

Review 15-2—Solution

a. Variable cost
b. Mixed cost
c. Committed fixed cost
d. Variable cost
e. Step cost
f. Discretionary fixed cost
g. Fixed cost (Without knowing the purpose of renting the car, the cost cannot be classified as committed or discretionary.)
h. Mixed cost
i. Step cost
j. Discretionary fixed cost

Review 15-3—Solution

Review 15-3—Solution

a. The cost of food sold was classified as a variable cost. Hence, the cost of food may be determined by dividing the total cost of food sold at either observation by the corresponding number of sandwiches.

$$b = \frac{\$1{,}575 \text{ total variable costs}}{2{,}100 \text{ units}}$$
$$= \$0.75X$$

Wages and salaries were previously classified as a mixed cost. Hence, the cost of wages and salaries is determined using the high-low method.

(variable cost)
$$b = \frac{\$1{,}675 - \$1{,}525}{2{,}700 - 2{,}100}$$
$$= 0.25X$$

(fixed cost)
$$a = \$1{,}525 \text{ total cost} - (\$0.25 \square 2{,}100) \text{ variable cost}$$
$$= \$1{,}000$$

Rent on building was classified as a fixed cost.

$$a = \$1{,}500$$

Total monthly costs most likely follow a mixed cost behavior pattern. Hence, they can be determined using the high-low method.

$$b = \frac{\$6{,}556 - \$5{,}848}{2{,}700 - 2{,}100}$$
$$= \$1.18X$$
$$a = \$5{,}848 - (\$1.18 \square 2{,}100)$$
$$= \$3{,}370$$
$$\text{Total costs} = \$3{,}370 \square \$1.18X$$

where

$$X = \text{unit sales}$$

b. and *c.*

Volume	Total Costs	Average Cost per Sandwich
1,000	$3,370 + ($1.18 × 1,000) = $4,550	$\frac{\$4{,}550}{\$1{,}000} = \$4.550$
2,000	$3,370 + ($1.18 × 2,000) = $5,730	$\frac{\$5{,}730}{\$2{,}000} = \$2.865$

The average costs differ at 1,000 and 2,000 units because the fixed costs are being spread over a different number of units. The larger the number of units, the smaller the average fixed cost per unit.

Review 15-4—Solution

Some common activity drivers for stating volume of activity in a manufacturing operation might include direct labor hours, machine hours, units of material produced, and units of finished product. The selection of the most appropriate basis requires judgment and professional experience. The relationship between the activity cost driver and the cost must seem logical and the activity data must be available.

Review 15-5—Solution

a. Unit-level
b. Store-level
c. Store-level
d. Unit-level
e. Customer-level
f. Order-level

Module 16