C CHAPTER 7

Cost Behavior

Learning Objectives

After reading this chapter, the student should be able to:

1. Define cost.
2. Distinguish variable from fixed cost for a service or process.
3. Distinguish direct from indirect cost for a responsibility center or service.
4. Allocate indirect costs to revenue centers using appropriate techniques.
5. Perform simple statistical cost analyses.
6. Perform simple cost/volume/profit analyses.

Key Terms

Activity-based costing
Cost
Cost allocation
Cost center
Cost drivers
Cost/volume/profit analysis
Direct allocation method
Direct cost
Double distribution method
Fixed cost
Indirect cost
Per-unit contribution margin
Reciprocal cost allocation method
Responsibility center
Revenue center
Shadow cost center
Step-down allocation method
Step-fixed cost
Variable cost

Controlling costs is not, strictly speaking, a financial function. Controlling costs involves attention to internal controls (rules for making purchases and for using assets), parsimony in spending, and the elimination of waste of materials and repetition of service. Process improvement staff, operating personnel, and purchasing authorities all play roles in cost control.

Most health care professionals, however, view cost control as being in the realm of financial management. The financial management staff certainly have a role in educating their colleagues as to the nature and level of cost. Managerial accountants, part of the financial team, are charged with measuring and analyzing costs. In addition, understanding the behavior of costs as volume changes (the subject of this chapter) is essential to carrying out the critical financial function of budgeting (the subject of Chapter 8).

After completing this chapter, the reader should be able to (1) allocate costs from cost centers to revenue centers, (2) perform simple statistical cost analyses, and (3) predict the level of service volume at which a health care organization can break even, equating its revenue to its costs.

COSTS

There may be no word more widely used, but more misunderstood, than **costs.** Consumers speak of what a service "costs" when they mean the price of the service. Policy analysts speak of national health care costs when they mean total national spending on health care. All of this verbal sloppiness is very confusing and obscures the meaning of costs as accountants, economists, and managers use it.

In accounting, economics, and managerial decision making, the cost of a good or service is its cost of production. That is, the cost of a home health visit is the market value of all of the resources that are employed in the delivery of that visit (Burik & Duval, 1985). The cost of an appendectomy and of a day's inpatient stay is the market value of *all* of the resources that are involved in delivering that appendectomy and overnight stay. The costs of producing a service are not neces-

sarily the same as the price that the consumer (or his insurance carrier) pays for the service. In fact, good managers work hard to keep cost well below price. Consumers pay a price; providers bear the cost.

Thus the costs of minor surgery and an overnight stay include the obvious items: the wholesale price (not the price charged to the patient) of the patient's food, the wholesale price of the surgical packs used, the wholesale price of all of the pharmaceuticals consumed, the wholesale price of laundry products, and the patient's share of the labor costs involved in delivering care. The cost of care also involves some indirect costs that are as real and as important as the obvious items. These include a share of the cost of construction and maintenance of the hospital building, a share of the cost of running the hospital's administrative units (administration, human resources, finance, marketing, patient accounts, information systems), and a share of the organization's financing costs. For society, the costs of care are greater than they are for the hospital. These nonhospital costs include the market value of physicians' services, the costs of home care after discharge, and any earnings the patient loses during illness and recovery.

For any organization, including health care providers, knowledge of costs is critical to sound management decision making. One can't control costs without knowing what they are. Without knowledge of what costs were in September, one cannot determine whether or not one is successful in controlling costs in October. For an organization to survive, the prices it charges must be at least as great as its costs. Pricing, then, depends on knowledge of costs. One cannot budget (plan) resource use for the next year without knowing what costs one is likely to incur during that period (the subject of Chapter 8).

Costs in Health Care

As important as knowledge of costs is to any organization, it is still rare among health care providers. As hospitals evolved during the late 19th and early 20th centuries (Stevens, 1999), they were either small adjuncts to physicians' practices or charitable organizations. Management expertise was in short supply. Overt concern with cost flew in the face of the ethos of charity. Hospital costs were simply ignored. Medical practices often kept track of their expenses but seldom had the resources or the inclination to determine the cost of any one service. Public health departments, often the most financially strapped health care organizations, were required to prepare financial reports for their governments, but were loathe to do any more involved analysis.

With the passage of the Social Security Amendments of 1965, particularly with the original structuring of Medicare payment, cost determination took on new meaning, at least in the hospital sector. Medicare Part A promised to "reimburse" hospitals for 80 percent of their "allowable costs" and required hospitals to file Medicare Cost Reports on which those reimbursements would be based. Parenthetically, it was this payment structure that introduced the myth that all payments to providers were merely "reimbursement" for costs incurred.

After 1965 hospitals not only were required to file cost data with the U.S. Health Care Financing Administration (administrators of the Medicare system, now the

Centers for Medicare and Medicaid Services) but also had incentives to treat their costs in a very special way. As discussed in the following section, the costs of facilities and administration can be allocated in any of several different ways. Medicare's cost-based payment system, and the adoption of similar systems by other third-party payors, provided hospitals with the incentive to allocate the most costs possible to the most generous payer. Cost finding was not intended to support managerial decision making but to maximize reimbursement. The cost accounting systems marketed and serviced by public accounting firms were not designed to support either cost control or budgeting but were "revenue maximization" systems (Balachandran & Dittman, 1978). Although investor-owned hospitals (and a few aggressive not-for-profit hospitals) had decision support systems for cost analysis, they represented only a very small share of hospitals and of hospital beds.

With the passage of the Social Security Amendments of 1983, Medicare "reimbursement" entered a new era, that of prospectively determined payment. The new payment system promised hospitals a fixed payment for each admission, based on diagnosis (Koch, 1999). Cost-based reimbursement was to become a thing of the past. Now cost analysis had a new function. The cost of caring for an angina patient, for example, was important, not because those costs would be reimbursed, but because the hospital needed to keep average angina care costs below their (fixed) Medicare payment level. It is in this prospective payment era that, slowly, cost analysis systems to support managerial decisions have been introduced into the hospital sector (Burik & Duval, 1985).

COSTS CLASSIFICATION

The cost of producing an item (a bandage, for example) or of providing a service (a bed-day in the medical unit) is the market value of all of the resources employed in producing the item or providing the service. Cost includes the market value of administrative inputs, outlays to repay financiers, and the periodic expenses associated with running an organization that are not tied to any single product or service (rent, utilities, and professional license fees, for example).

Costs can be classified in several *ways.* First, costs are either **direct** or **indirect.** Direct costs are those incurred directly as a result of providing a specific good or service. Thus, the direct cost of a bed day in the adult medicine unit of a hospital includes all resources tied directly to that bed day: nursing care, food consumed, drugs administered, and others. Indirect costs are those that, although *very* real, cannot be tied directly to the patient's stay in the bed. These include shares of depreciation, the cost of the administrative division, and the fixed costs (see below) of laundry and food service.

The direct/indirect distinction above is the one preferred by most accountants, as it focuses on the unit of service as the cost object. An older way of making the distinction focuses on the budget unit (or responsibility center, see below). In that view, costs incurred within the budget unit are direct, and costs incurred in other budget units are indirect to the unit in question.

Second, costs are **fixed, variable, or step-fixed.** Fixed costs are those that do not vary as service volume varies. Those include rent and utilities, which are set for each month regardless of whether or not any patients appear. Costs need not be immutable, forever unchanging, in order to be fixed. The definition of a fixed cost is only that it does not change as volume changes. Variable costs do change as volume changes.

Step-fixed (or semivariable) costs behave in complex ways. These are costs that are fixed over some range of service volume but rise to a new level for a higher range of service volumes. For example, three nurses may be needed if there are 5 or fewer patients on a floor. For 6 to 10 patients, however, one might need to call in a fourth nurse. Nursing costs, then, would be step-fixed: fixed over ranges, but changing in discrete increments as patient volume rises from range to range.

Figure 7–1 shows the classification of costs, for a hospital nursing unit, along two dimensions, direct/indirect and fixed/variable, and provides some examples. The salaries of the unit managers and the depreciation of the equipment specifically assigned to the unit are both direct (they can be tied directly to the care of specific patients) and fixed (they would be incurred even if the patient census were zero). Note that they are fixed with respect to patient census only, the managers' salaries could be increased by hiring more management.

The nursing unit will usually be assigned costs from other responsibility centers (discussed later). These are indirect from the standpoint of the unit's patients.

Variable costs change with patient volume. The purchase price of the syringes used within the nursing unit (and of other supplies) varies with patient volume, as do the wages paid to nurses on call by the unit. These are both variable and direct.

Algebraically, total costs (TC) equals fixed costs (FC) plus variable cost per unit (VC_u) times the quantity of units delivered (Q):

$$TC = FC + (VC_u \times Q)$$

	Direct	Indirect
Fixed	- Salaries of unit managers - Depreciation of unit equipment	- Allocated depreciation of facility - Allocated salaries from administration
Variable	- Supplies - Wages of nurses on call	

Figure 7-1 Classification of costs for a nursing unit.

RESPONSIBILITY CENTERS

Costs occur somewhere. The places where costs occur, and which have budgets, are called **responsibility centers.** A responsibility center is a subunit of the larger organization that is responsible for some type of budget. Responsibility center accounting, the assignment of costs to responsibility centers and the evaluation of the budgetary and cost-control performance of those centers, is an important component of internal control and good budget practice.

Some responsibility centers, **cost centers,** are charged with managing their costs only. Cost centers have no revenue budgets (see Chapter 8 for definitions of the various types of budgets) and no obligation to earn revenues for the organization. *Administration is* always a cost center, as are *human resources* and *housekeeping.* Being a cost center does not make a unit any less important than any other unit in the organization. For example, in many hospitals, nursing (to the great chagrin of many nurses) is a cost center. Although it is true that a hospital cannot function without nursing service, nursing's being a cost center merely means that, in those hospitals, "nursing service" does not bill for its services. Managers who starve cost centers in order to control organizational costs are not practicing good management.

Some cost centers, **shadow cost centers,** exist as budgets on paper only. For example, *rent and utilities* and *depreciation of plant and equipment* are large-budget items for any organization. These are cost centers even though there is no one in the center. For cost allocation purposes, however, rent, utilities, and depreciation need to be treated as cost centers.

Those centers that are charged with controlling costs and with generating revenue for the organization are **revenue centers.** A revenue center is charged with both an expense budget and a revenue budget. It is evaluated on its ability to meet the goals embedded in its revenue budget. An organization's revenue centers, collectively, have the obligation to meet, through their production of revenues, the costs of all cost centers and of all revenue centers.

COST ALLOCATION: MANAGERIAL DECISIONS UNDER AMBIGUITY

Revenue centers, collectively, must meet the total costs of their organizations. In order to determine how effectively any one revenue center is doing its share in meeting costs, one must allocate to that revenue center its proper share of cost centers' costs. This section and the one that follows present simplified models of cost **allocation** and discuss their effects on managerial decisions. Readers wishing to study these methods in greater detail should consult a textbook on managerial accounting (Finkler & Ward, 1999).

In the cost allocation process, one assigns to every responsibility center benefiting from the services of cost center X some share of the costs generated in center X. Thus, as every responsibility center in the organization "benefits" from the services of the chief executive's office, every center is assigned a share of the costs of that office. Any cost allocation is based on (1) an allocation method and (2) a set of allocation criteria.

Suver, Neumann, and Boles (1992) describe four cost allocation methods: direct, step-down, double distribution, and reciprocal. Figures 7–2 through 7–6 show how costs would be allocated in a simple organization, Sample Clinic, using the direct and step-down methods, respectively. Sample Clinic has two revenue centers, pediatrics and adult medicine. These are served by six cost centers: rent and utilities (a shadow center), the executive office, financial affairs, imaging, nursing, and the laboratory. The cost allocation problem for Sample Clinic is to allocate the costs generated in the six cost centers to the two revenue centers.

Direct Allocation Method

The **direct allocation method** is the easiest to implement, but it ignores intermediate cost flows. Figure 7—2 shows that, under direct allocation, all costs incurred in each of the cost centers are allocated, through some set of allocation criteria, directly to the revenue centers, with no intermediate allocations. That the financial affairs office enjoys the services of rent and utilities is ignored in this allocation method.

Step-Down Allocation Method

The **step-down allocation method,** although somewhat more difficult to implement, improves on the direct allocation method by recognizing intermediate cost flows. Figure 7—3 illustrates the first steps in that method. In the first step, responsibility centers are arrayed in a hierarchy. At the top of that hierarchy is the center that provides resources to the most other centers, in this case, rent and utilities. The costs of that "top" center are then allocated, according to the appropriate allocation criterion, to all other centers. After all of the costs of the "top" center are allocated, it is "closed." Once the top responsibility center is closed, no costs are allocated to it.

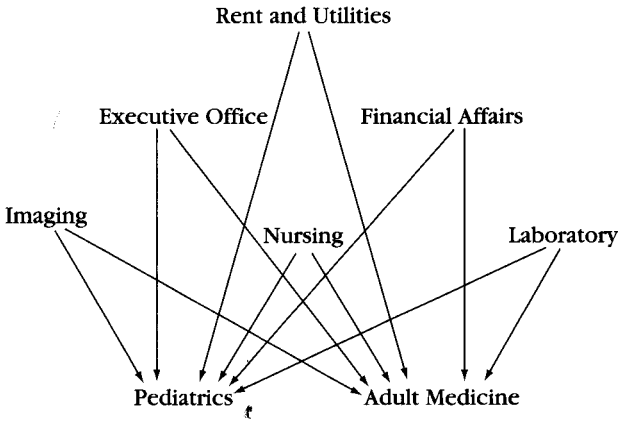

Figure 7–2 Direct cost allocation, Sample Clinic (adapted from Balachandran & Dittman, 1978).

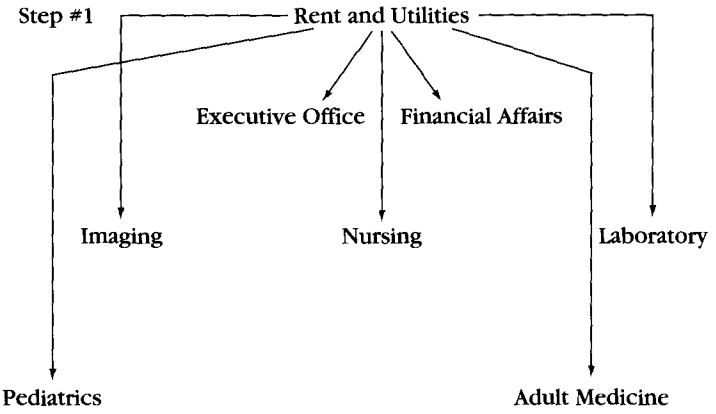

Figure 7–3 Step-down cost allocation, Sample Clinic (adapted from Balachandran & Dittman, 1978).

Figure 7—4 shows the second step in the step-down process. Rent and utilities has been closed. Now all of the costs (including those that were allocated from rent and utilities) of the next center (or centers) in the hierarchy are allocated to the remaining responsibility centers. In this case, all of the costs of the executive office (including the costs that were allocated to the executive office from rent and utilities) are allocated, via application of the appropriate allocation criterion, to the remaining responsibility centers. The executive office is then closed and no costs are allocated to it.

Figures 7—5 and 7—6 show the remainder of the step-down process, with all of the costs (including those allocated from above) being allocated down from each succeeding layer of responsibility centers. The process ends when all cost centers have been closed and all of the organization's costs are allocated to the revenue centers.

Double or Multiple Distribution Method

The **double (or multiple) distribution method** of cost allocation improves on the step-down method by recognizing that resources flow in more than one direction. For example, in Sample Clinic, financial affairs enjoys the supervision and direction of the executive office, but also may provide services (analysis, counseling) to the executive office. In the double distribution method, centers are not closed on the first pass of costs through the hierarchy of responsibility centers. Rather, during the first pass through the hierarchy, costs are allocated "upward" as appropriate. Only in the second pass through the hierarchy (double distribution) or in some later pass (multiple distribution) are centers closed. The process ends when all of the organization's costs are allocated to the revenue centers.

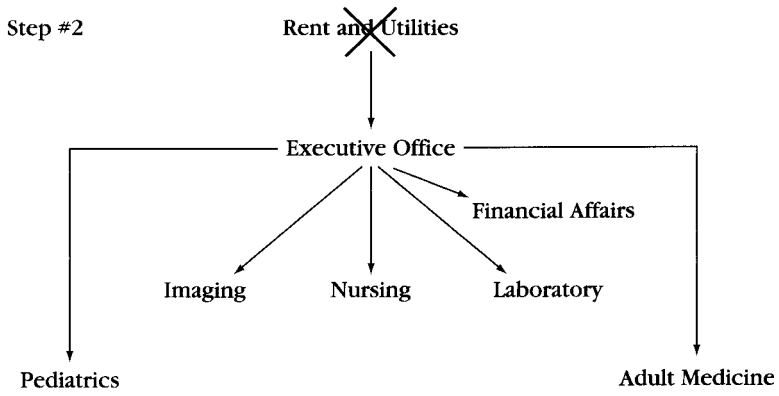

Figure 7–4 Step-down allocation, continued.

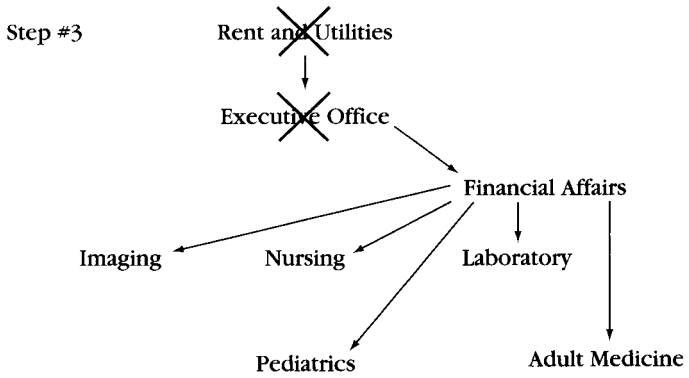

Figure 7–5 Step-down allocation, continued.

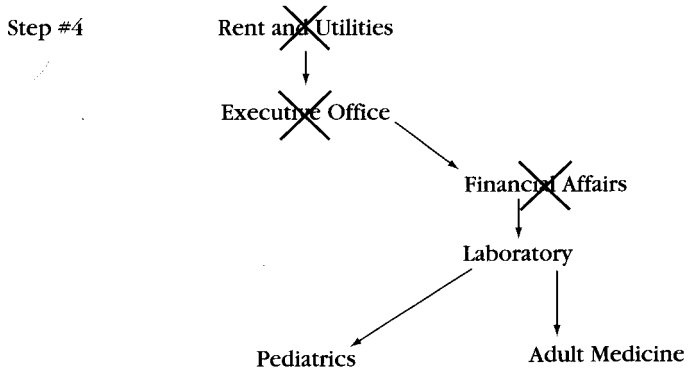

Figure 7–6 Step-down allocation, continued.

Reciprocal Cost Allocation Method

The recognition that resources flow in many directions among responsibility centers is pushed to the limit in the application of the **reciprocal cost allocation method.** That method recognizes that resources flow from every responsibility center to every other responsibility center. Once considered too complex to manage, reciprocal cost allocation problems can be treated as solutions to matrix problems with modern spreadsheet software. The end result of this allocation process, like that of every other, is to allocate all of the organization's costs to its revenue centers.

ALLOCATION CRITERION

The allocation of costs from any one center to other centers, whichever allocation method is used, depends on an allocation criterion. The allocation criterion is the rule for how to divide the costs of Center A among the centers it serves. For example, the costs of rent and utilities might reasonably be divided among the other centers on the basis of each center's proportion of net allocatable square feet of space. The costs of financial affairs might be divided according to each center's percentage of budget (taking care that it is the percentage of the budget of centers below financial affairs in the hierarchy that is used). The cost of the human resources office might be divided according to each center's percent of payroll (again, payroll of centers below human resources in the hierarchy). There is no one correct criterion for allocating the cost of any responsibility center. One must, however, take care to ensure that the allocation criteria for fixed costs used are not functions of service volume. To allocate indirect fixed costs on the basis of service volume (percent of bed-days, percent of inpatient visits) would be to treat fixed costs as if they were variable costs.

Table 7—1 shows the step-down allocation of monthly costs for fictitious Sample Clinic. The hierarchy of responsibility centers shown is the same as that in Figures 7—3 through 7—6. The allocation criteria are given next to the name of each center. Rent and utilities is to be allocated on a percentage-of-square-feet basis (the square feet for the responsibility centers, including public spaces, are also shown). Thus, because the executive office occupies 17 percent of total square feet, it is allocated 17 percent ($2,482.76) of total monthly rent and utilities. After the $15,000 in rent and utility costs are allocated to the other seven responsibility centers, rent and utilities is closed.

In the second step, the executive office has its own $12,000 of direct cost to allocate to other responsibility centers, *plus* the $2,482.76 that it was allocated from rent and utilities. These costs are allocated on the basis of percentage of direct cost. Of the total $14,482.76 to be allocated from the executive office, the financial office will be allocated $428.77, because direct costs in that responsibility center constitute 2.96 percent of total direct costs for those responsibility centers below the executive office in the hierarchy. After the executive office's $14,482,76 in total costs are allocated, it is closed.

Table 7–1 Step-down cost allocation, Sample Clinic

	To							
From	**Direct Cost**	**Executive Office**	**Financial Affairs**	**Imaging**	**Nursing**	**Laboratory**	**Pediatrics**	**Adult Medicine**
Rent and utilities (percentage of square feet)	$15,000	$2,482.76	$517.24	$1,241.38	$413.79	$1,241.38	$4,137.93	$4,965.52
Executive office (direct cost as percentage of total)	12,000		428.77	1,191.02	1,524.50	2,096.19	4,287.66	4,954.63
Financial affairs (direct cost as percentage of total)	4,500			461.53	590.75	812.29	1,661.49	1,919.95
Imaging (direct cost as percentage of total)	12,500						7,141.51	8,252.41
Nursing (direct cost as percentage of total)	16,000						8,595.95	9,933.10
Laboratory (direct cost as percentage of total)	22,000						12,131.38	14,018.48
Pediatrics	45,000							
Adult medicine	52,000							
Total	179,000						82,955.92	96,044.08

	Square Feet	*Percentage of Total*
Executive office	1,200	0.17
Financial affairs	250	0.03
Imaging	600	0.08
Nursing	200	0.03
Laboratory	600	0.08
Pediatrics	2,000	0.28
Adult medicine	2,400	0.33
Total	7,250	1.00

In the third step, financial affairs' costs are allocated. These include the $4,500 in direct costs *plus* the $517.24 that it was allocated from rent and utilities *plus* the $428.77 that it was allocated from the executive office. The total costs of financial affairs are then allocated on a percentage-of-direct-cost basis, where the percent of direct cost is based on the direct costs of the responsibility centers below financial affairs in the allocation hierarchy. After all of the costs of the financial office have been allocated, it is closed.

At the end of the process, all of the organization's costs ($179,000) have been allocated to the two revenue centers ($82,955.92 + $96,044.08 = $179,000). Remember that different allocation criteria lead to different final cost allocations. Use of another allocation method, such as reciprocal allocation, would also change the final allocation. Decisions based on the cost of operating the pediatric product line in Sample Clinic, then, are based on ambiguous information. There is no one correct measure of the monthly cost of operating that revenue center.

THE ABCS OF ABC

One of the most important recent innovations in cost analysis has been the development of **activity-based costing (ABC)** (Baker, 1998; Chan, 1993). ABC has helped to identify the costs of particular services better than was previously possible, and has been a valuable tool in the performance evaluation approach known as the "Balanced Scorecard" (Kaplan and Norton, 1992).

In a traditional (pre-ABC) approach, costs are allocated to revenue centers (as above, and the allocation process stops). If a revenue center has more than one service line (as is usually the case), costs are simply divided among those service lines, often on a "per visit" or "per bed day" basis. The similarity to spreading peanut butter evenly on a slice of bread has given this process the derogatory name "peanut butter costing." Peanut butter costing can lead to overestimation of the costs of some services and underestimation of the costs of others.

ABC seeks to improve on the shortcomings of peanut butter costing by identifying the cost **drivers** that use resources within a revenue center. Consider a clinical laboratory. A hemoglobin Al-c test uses more resources than a simple serum glucose measurement (both are used in the assessment of diabetic control). Peanut butter costing allocates the same cost to each. ABC costing identifies the drivers that move cost, such as set-up time, and allocates the laboratory's cost based on each test's use of those drivers. The result is that the cost object, or cost pool, is the service, not the center. In a system in which the costs of specific diagnoses, and, therefore, specific product lines, are important inputs into decisions, ABC has become an important tool, indeed.

SEPARATING FIXED AND VARIABLE COSTS

Just as finding the total (direct plus indirect) cost of a service or of a revenue center is essential to good budgeting and decision making, so is separating fixed from variable cost. A service that at least meets its variable cost of production makes a contribution to meeting the organization's fixed cost and ought, at least in the

short-run, to be continued. Decisions as to which services to keep, which to terminate, and which to subject to flexible budgeting (discussed in Chapter 8) require that one be able to separate the fixed and variable components of costs.

Unfortunately, costs rarely come with their fixed and variable components broken down. Rather, one is usually faced with data on the total costs of operating a responsibility center, if one has cost data at all. Also, whereas some costs are clearly fixed (depreciation, for example) and others are clearly variable (vials of vaccine for a public health clinic), others cannot be identified as fixed or variable before the fact. The fixed / variable distinction is, ultimately, an empirical question.

Two methods are widely used for separating fixed and variable costs: the high-low method and least squares regression analysis. The latter has become, with advances in spreadsheet software, so easily applied that it has largely replaced the former. Table 7–2 extends the cost analysis of fictitious Sample Clinic's pediatric revenue center. The allocated overhead cost column reflects the amount of indirect costs that are allocated to pediatrics each month. *Overhead is* only another way of expressing *fixed costs.* Various numbers of visits are recorded for each month in a sample year. Figure 7–7 shows the cost data graphically. The figure reveals data on direct fixed and variable costs that would not be available to a decision maker without detailed analysis. The reader can easily verify that variable costs per unit are $30. The director of the pediatric center does not yet know that. What the clinic director knows is revealed in Table 7-3.

High-Low Method

The *high-low method is* very simple, easy to apply, and accurate over small ranges of output. The method is shown in Table 7-4. In the high-low method, one selects one high-volume month (it need not be the month with the highest volume) and one low-volume month (it need not be the month with the lowest volume).

Table 7–2 Sample Clinic, monthly costs for pediatrics

Month	Visits	Allocated Overhead Costs	Direct Fixed Costs	Variable Costs	Total Costs
January	600	$83,000	$45,000	$18,000	$146,000
February	660	83,000	45,000	19,800	147,800
March	630	83,000	45,000	18,900	146,900
April	570	83,000	45,000	17,100	145,100
May	525	83,000	45,000	15,750	143,750
June	480	83,000	45,000	14,400	142,400
July	390	83,000	45,000	11,700	139,700
August	460	83,000	45,000	13,800	141,800
September	660	83,000	45,000	19,800	147,800
October	700	83,000	45,000	21,000	149,000
November	715	83,000	45,000	21,450	149,450
December	680	83,000	45,000	20,400	148,400

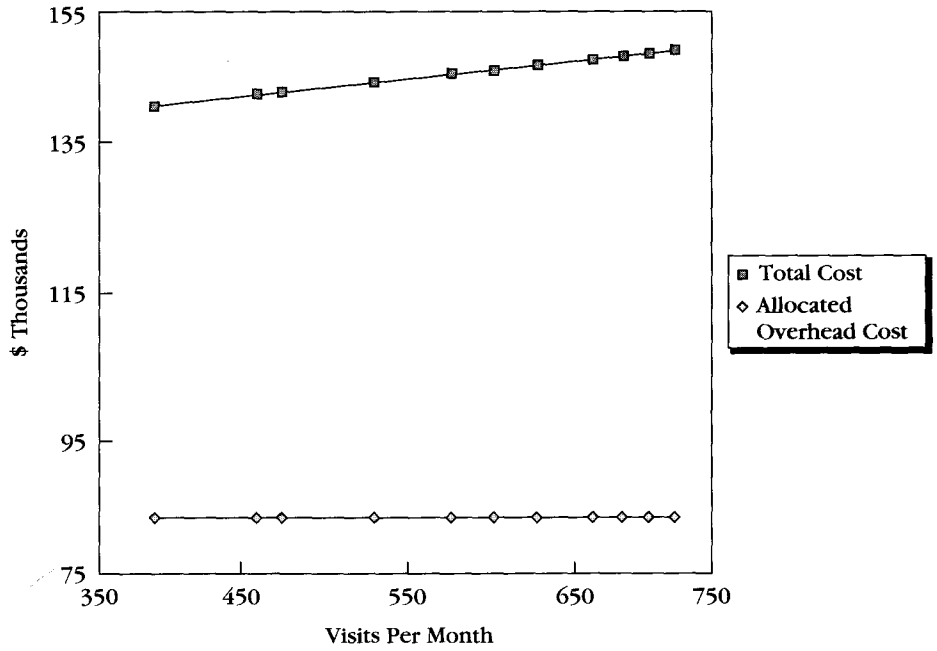

Figure 7–7 Sample Clinic, monthly cost of pediatrics

Table 7–3 Sample Clinic monthly costs for pediatrics: what the clinic director knows

Visits	Allocated Overhead Costs	Total Costs
390	$83,000	$139,700
460	83,000	141,800
480	83,000	142,400
525	83,000	143,750
570	83,000	145,100
600	83,000	146,000
630	83,000	146,900
660	83,000	147,800
660	83,000	147,800
680	83,000	148,400
700	83,000	149,000
715	83,000	149,450

Subtracting the low volume from the high volume and the associated low cost from the associated high cost, one determines how much total costs will change for a given change in volume. In Table 7—4 a change of 325 visits per month causes a change of $9,750 in total cost.

All of the change in total cost associated with the change in total volume must be variable cost. Fixed costs, by definition, don't change as volume changes.

Table 7–4 Sample Clinic: pediatrics breakdown of fixed and variable costs, high-low method

	Visits	Total Costs
High month	715	$149,450
Low month	390	139,700
Difference	325	9,750

Variable cost/Unit = $9750/325 = $30

High-month fixed cost = TC − ($VC_u \times Q$)
= $149,450 − ($30 × 715)
= $128,000

Dividing the total change in cost by the change in volume, then, yields variable cost per unit *($9750/325* = $30).

Remember that total cost is equal to fixed cost plus the product of variable cost per unit and quantity of units. In equation form:

$$TC = FC + (VC_u \times Q)$$

Using the high-volume month, one knows that fixed cost is equal to total cost minus variable cost per unit times the number of units (quantity). Subtracting variable cost per unit ($30) times quantity *(715)* from total cost, one finds that monthly fixed cost is $128,000. Because *$83,000* of that fixed cost is allocated overhead, it follows that $45,000 must be the monthly direct fixed cost of the pediatric clinic. These results are consistent with the data in Table *7-2*.

The high-low method works well when variable cost per unit is constant and when fixed costs do not change over the time period used. When fixed costs vary widely (for example, when utility bills are very different in the summer and winter months, or when a new facility has been opened between the high-volume and low-volume months), the high-low method is less reliable.

Least Squares Regression Analysis

An alternative to the high-low method is the use of ordinary least squares regression analysis to separate fixed and variable costs. Regression analysis, properly employed, is a powerful, flexible tool. Contemporary students and financial analysts are fortunate in that regression analysis is now a standard feature of spreadsheet software. Readers unfamiliar with the method should consult a textbook on econometrics (Lardaro, 1993, especially chapters 4 and *5;* Maddala, 1992, especially chapter *3).*

To use the linear regression model to separate fixed and variable costs, one specifies a model of the form

$$Y = a + \beta X$$

or

Total cost = Fixed cost + (Variable cost per unit x Quantity)

That is, total cost is specified as determined by a causal relationship in the form of a straight line. Total cost is the dependent variable, fixed cost is the estimated intercept term (what total cost would equal were volume equal to zero), and variable cost per unit is the estimated coefficient (fi) of quantity (the independent variable). In the language of spreadsheets, the column labeled Total Cost in Table 7—3 is the Y-range (the dependent variable) and the column labeled Visits is the X-range (the independent variables).

Table 7—5 shows the Output Range from a spreadsheet regression, estimating the fixed and variable cost components from Table 7—3. The constant" ($128,000) is the estimated value for fixed cost. The estimated X coefficient shows variable cost per unit, how much the dependent variable (total cost) changes with a one unit change in the independent variable (service volume or quantity). That estimated variable cost per unit is $30. As was the case for the high-low method, the regression model yields an estimated fixed cost per month of $128,000.

R-squared indicates the proportion of the total variation in the dependent variable that is explained by the model. In this case, but seldom in real life, the relationship is exact and R squared is at its maximum value, 1.00. Because the relationship estimated is exact, the test for the statistical significance of the estimated coefficient is trivial, the standard error of the coefficient is 0.00. In most cases, one would need to divide the estimated coefficient by its standard error. The resulting t-statistic should then be subjected to a significance test to determine whether variable cost per unit is, in fact, significantly different from zero.

What is the advantage of using statistical cost analysis rather than the high-low method? Regression is a more "robust" method. It works even if fixed costs are nonconstant (so long as the analyst can model the causes of the change in fixed cost). Linear regression is also, in the age of desktop computing, easy. With only a spreadsheet, one can run regressions instantly, at the touch of a button

Finally, the use of linear regressing allows the development of richer models of more complex cost behavior. For example, a clinic offering both vaccinations (X_1) and well-baby visits (X_2) might specify and estimate a cost function of the form:

$$TC = \alpha + \beta_1 X_1 + \beta_2 X_2,$$

Table 7–5 Sample Clinic: Pediatrics breakdown of fixed and variable costs, linear regression method

Regression Output	
Constant	$128,000.00
Std. err. of *Y* est	0.00
R squared	1
No. of observations	12
Degrees of freedom	10
X coefficient(s)	30.00
Std err of coef.	0.00

where a is estimated fixed cost, 13_1 is estimated variable cost per unit for vaccinations, and (3_2 is estimated variable cost per unit for well-baby visits.

Sometimes, fixed costs change within a data collection period. Consider the case of moving to a new facility and wanting to know the effect of the move on costs. Our clinic could model:

$$TC = \alpha + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3,$$

where the initial variables are interpreted as above, and $X_3 = 1$ for months in the new facility and $X_3 = 0$ otherwise. 13_3, then, is the estimated effect of the new facility on fixed costs.

COST-VOLUME-PROFIT ANALYSIS, TRADITIONAL

The previous sections showed how costs will behave as volume changes and how to separate fixed from variable costs. The **cost-volume-profit (CVP) analysis** model is a useful framework for analyzing that information (Cleverly, 1979).

Consider Sample Clinic's pediatric unit once again. No matter what its monthly volume, it generates $45,000 in direct fixed cost and is assigned $83,000 in overhead costs. Each visit generates $30 in variable cost (variable cost per unit, VC,). Suppose the pediatric clinic charges $50 per visit. The $50 is the price of a visit, or revenue per unit (R,). Each visit, then, contributes $50—$30 toward meeting Sample Clinic's fixed cost. That amount is the **per-unit contribution margin** of a pediatric visit. It represents what each pediatric visit contributes toward meeting the clinic's fixed costs.

To find how many visits would be necessary for the pediatric unit to break even, begin with the formula:

$$\text{Total cost} = \text{Fixed cost} + (\text{VC}_u \times Q)$$

The formula for total revenue is

$$\text{Total revenue} = (R_u \times Q)$$

At the breakeven quantity (Q^*), total revenue equals total cost, so

$$(R_u \times Q^*) = \text{Fixed cost} + (\text{VC}_u \times Q^*)$$

To solve for Q*, breakeven quantity,

$$(R_u \times Q^*) - (\text{VC}_u \times Q^*) = \text{Fixed cost}$$

$$(R_u - \text{VC}_u) \times Q^* = \text{Fixed cost}$$

$$Q^* = \frac{\text{Fixed cost}}{(R_u - \text{VC}_u)}$$

Breakeven quantity = Fixed cost/per-unit contribution margin

For the case at hand, breakeven quantity in the pediatric unit is $128,000/$20, or 6,400 visits per month. Does that mean that the pediatric unit should be shut

down? Not necessarily. Note that $83,000 of Pediatrics' fixed cost is allocated overhead, costs that Sample Clinic would incur even if there were no pediatric unit. If the unit covers its direct costs (fixed and variable) and makes *any* contribution to overhead, it is worth keeping, even in the long run. Further, in the short run, Pediatrics cannot eliminate its own fixed cost ($45,000). In the short run, if the unit has a positive contribution margin (as it does), it should continue to operate to make a contribution to its own fixed costs. In the long run, if the unit cannot meet its own (direct) total costs, it should be eliminated, unless some outside entity or another revenue center is to subsidize it.

COST-VOLUME-PROFIT ANALYSIS, CAPITATION

The discussion above assumed that the provider is paid for each unit of service provided. Many health care providers face the situation in which total revenue per period is fixed, based on the receipt of per-member-per-month (PMPM) payments for an enrolled population. The fixed total revenue model is familiar in many settings: veterans' medical centers, Indian health service hospitals, primary care physicians' practices in the British National Health Service, hospitals and polyclinics in the countries of the former Soviet Union, as well as in pure health maintenance organizations in the U.S.

Let toal revenue be fixed: *TR.* Total cost is still given by

$$TC = FC + (VC_u \times Q).$$

Setting the two equal and solving yields a breakeven quantity of

$$Q^* = (\overline{TR} - FC) \; / \; VC_u.$$

If we call *(TR* – FC) our "monthly cushion," then each unit of service eats away VC_u of that cushion. At service levels *above Q*,* the provider suffers a loss. Boles and Fleming (1996) provide an interesting discussion of capitated providers' incentives to control enrollees' utilization of services.

SUMMARY

The cost of a health care service is the market value of the real resources used to produce that service. Knowledge of costs is important for budgeting, planning, and evaluating the adequacy of pricing structures.

Young and Pearlman (1993) have proposed that every health care organization implement a four-step process that integrates cost finding with managerial decision making. In the first stage, the organization would improve its systems for collecting cost data (its cost accounting systems). In the second stage, the organization would separate fixed from variable costs (determine its cost behavior patterns). In the third stage, the organization would identify its "cost drivers" and look for ways to control its costs (engage in feedback and managerial cost control). In the fourth stage, cost information is used as input into redesigning the organization and its tasks. That process, and the four stages that it incorporates, provides a way to use cost information to enhance organizational performance.

Modern computing equipment and relatively elementary statistical analysis make identification of costs possible for every health care organization. When costs are known, they can be controlled. With knowledge of costs, one can employ other models, such as cost/volume/profit analysis, that enable one to make better decisions.