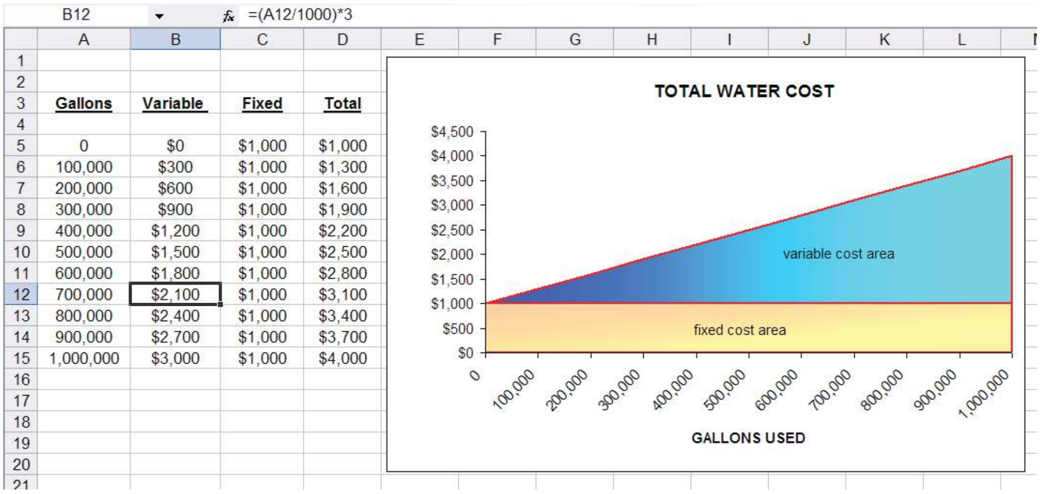
2 Cost Behavior Analysis

Good managers must not only be able to understand the conceptual underpinnings of cost behavior, but they must also be able to apply those concepts to real world data that do not always behave in the expected manner. Cost data are impacted by complex interactions. Consider for instance the costs of operating a vehicle. Conceptually, fuel usage is a variable cost that is driven by miles. But, the efficiency of fuel usage can fluctuate based on highway miles versus city miles. Beyond that, tires wear faster at higher speeds, brakes suffer more from city driving, and on and on. Vehicle insurance is seen as a fixed cost; but portions are required (liability coverage) and some portions are not (collision coverage). Furthermore, if you have a wreck or get a ticket, your cost of coverage can rise. Now, the point is that assessing the actual character of cost behavior can be more daunting than you might first suspect. Nevertheless, management must understand cost behavior, and this sometimes takes a bit of forensic accounting work. Let's begin by considering the case of "mixed costs."

2.1 Mixed Costs

Many costs contain both variable and fixed components. These costs are called mixed or semi variable. If you have a cell phone, you probably know more than you wish about such items. Cell phone agreements usually provide for a monthly fee plus usage charges for excess minutes, text messages, and so forth. With a mixed cost, there is some fixed amount plus a variable component tied to an activity. Mixed costs are harder to evaluate, because they change in response to fluctuations in volume. But, the fixed cost element means the overall change is not directly proportional to the change in activity.

To illustrate, assume that Butler's Car Wash has a contract for its water supply that provides for a flat monthly meter charge of $1,000, plus $3 per thousand gallons of usage. This is a classic example of a mixed cost. Below is a graphic portraying Butler's potential water bill, keyed to gallons used:



Gallons	Variable	Fixed	Total
0	$0	$1,000	$1,000
100,000	$300	$1,000	$1,300
200,000	$600	$1,000	$1,600
300,000	$900	$1,000	$1,900
400,000	$1,200	$1,000	$2,200
500,000	$1,500	$1,000	$2,500
600,000	$1,800	$1,000	$2,800
700,000	$2,100	$1,000	$3,100
800,000	$2,400	$1,000	$3,400
900,000	$2,700	$1,000	$3,700
1,000,000	$3,000	$1,000	$4,000

Look closely at the data in the spreadsheet, and notice that the "variable" portion of the water cost is $3 per thousand gallons. For example, spreadsheet cell B12 is $2,100 (700 thousand gallons at $3 per thousand); observe the formula for cell B12 in the upper bar of the spreadsheet (=(A12/1000)*3). In addition, the "fixed" cost is $1,000, regardless of the gallons used. The total in column D is the summation of columns B and C. The cost components are mapped in the diagram at the right.

Hopefully, the preceding illustration is clear enough. But, what if you were not given the "formula" by which the water bill is calculated? Instead, all you had was the information from a handful of past water bills. How hard would it be to to sort it out? Could you estimate how much the water bill should be for a particular level of usage? This type of problem is frequently encountered in business, as many expenses (individually and by category) contain both fixed and variable components.

2.2 High-Low Method

One approach to sorting out mixed costs is the high-low method. It is perhaps the simplest technique for separating a mixed cost into fixed and variable portions. However, beware that it can return an imprecise answer if the data set under analysis has a number of rogue data points. But, it will work fine in other cases, as with the water bills for Butler's Car Wash. Information from Butler's actual water bills is shown at above right. Butler is curious to know how much the August water bill will be if 650,000 gallons are used. Assume that the only data available are from the aforementioned four water bills.

With the high-low technique, the highest and lowest levels of activity are identified for a period of time. The highest water bill is $3,550, and the lowest is $2,020. The difference in cost between the highest and lowest level of activity represents the variable cost ($3,550 – $2,020 = $1,530) associated with the change in activity (850,000 gallons on the high end and 340,000 gallons on the low end yields a 510,000 gallon difference). The cost difference is divided by the activity difference to determine the variable cost for each additional unit of activity ($1,530/510 thousand gallons = $3 per thousand).

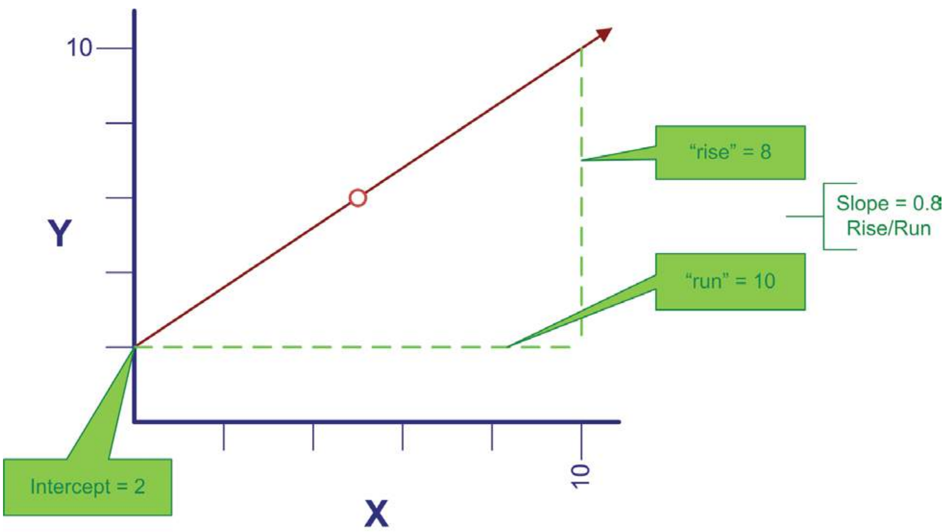
The fixed cost can be calculated by subtracting variable cost (per-unit variable cost multiplied by the activity level) from total cost. The table at above right reveals the application of the high-low method. An electronic spreadsheet can be used to simplify the high-low calculations. The website includes a link to an illustrative spreadsheet for Butler.

2.3 Method of Least Squares

As cautioned, the high-low method can be quite misleading. The reason is that cost data are rarely as linear as presented in the preceding illustration, and inferences are based on only two observations (either of which could be a statistical anomaly or "outlier"). For most cases, a more precise analysis tool should be used. If you have studied statistical methods, recall "regression analysis" or the "method of least squares." This tool is ideally suited to cost behavior analysis. This method appears to be imposingly complex, but it is not nearly so complex as it seems. Let's start by considering the objective of this calculation.

The goal of least squares is to define a line so that it fits through a set of points on a graph, where the cumulative sum of the squared distances between the points and the line is minimized (hence, the name "least squares"). Simply, if you were laying out a straight train track between a lot of cities, least squares would define a straight-line route between all of the cities, so that the cumulative distances (squared) from each city to the track is minimized.

Let's dissect this method, beginning with the definition of a line. A line on a graph can be defined by its intercept with the vertical (Y) axis and the slope along the horizontal (X) axis. In the following diagram, observe a red line starting on the Y axis (at the value of "2"), and rising gently upward as it moves out along the X axis. The rate of rise is called the slope of the line; in this case, the slope is 0.8, because the line "rises" 8 units on the Y axis for every 10 units of "run" along the X axis.



In general, a straight line can be defined by this formula:

$$Y = a + bX$$

where:

a = the intercept on the Y axis
b = the slope of the line
X = the position on the X axis

For the line drawn on the previous page, the formula would be:

$$Y = 2 + 0.8X$$

And, if you wished to know the value of Y, when X is 5 (see the red circle on the line), you perform the following calculation:

$$Y = 2 + (0.8 * 5) = 6$$

Now, lets move on to fitting a line through a set of points. On the next page is a table of data showing monthly unit production and the associated cost (sorted from low to high). These data are plotted on the graph to the right. Through the middle of the data points is drawn a line, and the line has a formula of:

$$Y = \$138,533 + \$10.34X$$

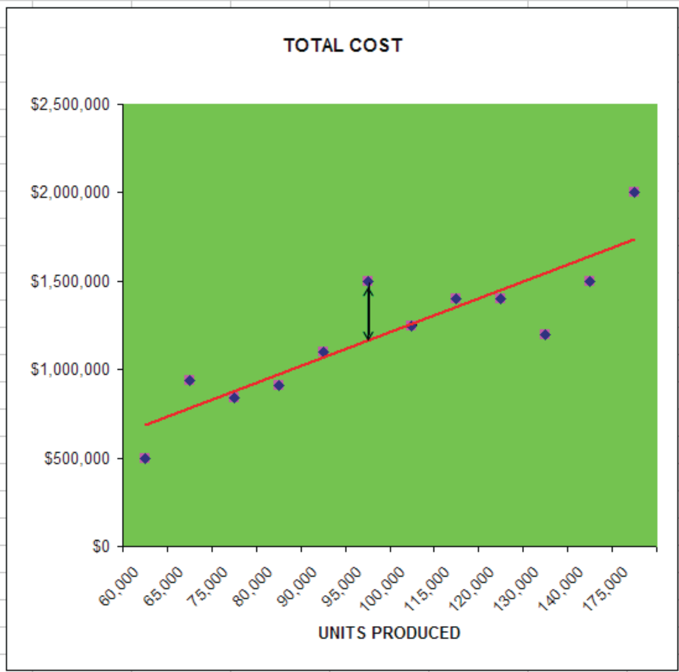
This formula suggests that fixed costs are $138,533, and variable costs are $10.34 per unit. For example, how much would it cost to produce about 110,000 units? The answer is about $1,275,000 ($138,533 + ($10.34 * 110,000)).

How was the formula derived? One approach would be to "eyeball the points" and draw a line through them. You would then estimate the slope of the line and the Y intercept. This approach is known as the scatter graph method, but it would not be precise. A more accurate approach, and the one used to derive the above formula, would be the least squares technique. With least squares, the vertical distance between each point and resulting line (e.g., as illustrated by an arrow at the $1,500,000 point) is squared, and all of the squared values are summed. Importantly, the defined line is the one that minimizes the summed squared values! This line is deemed to be the best fit line, hopefully giving the clearest indication of the fixed portion (the intercept) and the variable portion (the slope) of the observed data.

One can always fit a line to data, but how reliable or accurate is that resulting line? The R-Square value is a statistical calculation that characterizes how well a particular line fits a set of data. For the illustration, note (in cell B21) an R2 of .798; meaning that almost 80% of the variation in cost can be explained by volume fluctuations. As a general rule, the closer R2 is to 1.00 the better; as this would represent a perfect fit where every point fell exactly on the resulting line.

B21 =RSQ(C5:C16,B5:B16)

Month	Units	Cost
Oct	60,000	$500,000
Nov	65,000	$940,000
Mar	75,000	$840,000
Sep	80,000	$910,000
Feb	90,000	$1,100,000
Dec	95,000	$1,500,000
Jan	100,000	$1,250,000
Aug	115,000	$1,400,000
Apr	120,000	$1,400,000
Jun	130,000	$1,200,000
May	140,000	$1,500,000
Jul	175,000	$2,000,000
Intercept	138533.27	
Slope	10.343454	
R square	0.7985868	



The R-Square method is good in theory. But, how does one go about finding the line that results in a minimization of the cumulative squared distances from the points to the line? One way is to utilize built-in tools in spreadsheet programs, as illustrated above. Notice that the formula for cell B21 (as noted at the top of spreadsheet) contains the function RSQ(C5:C16,B5:B16). This tells the spreadsheet to calculate the R2 value for the data in the indicated ranges. Likewise, cell B20 is based on the function SLOPE (C5:C16,B5:B16). Cell B19 is INTERCEPT(C5:C16,B5:B16). Most spreadsheets provide intuitive pop-up windows with prompts for setting up these statistical functions.

Spreadsheets have not always been available. You may be curious to know the underlying mechanics for the least squares method. If so, you can check out the link on the website.

2.4 Recap

Before moving on, let's review a few key points. A good manager must understand an organization's cost structure. This requires careful consideration of variable and fixed cost components. However, it is sometimes difficult to discern the exact cost structure. As a result, various methods can be employed to analyze cost behavior. Once an organization's cost structure is understood, it then becomes possible to perform important diagnostic calculations which are the subject of the next sections of this chapter.