The Reality of Costs

By Reginald Tomas Yu-Lee

Executive Summary

Total cost has traditionally been expressed as the sum of fixed and variable costs. This model is based on the assumption that all costs are either independent of production volumes or that they vary with respect to production volumes. This assumption limits understanding of cost behavior and can lead to decisions with unanticipated results.

One traditional definition of cost in a production environment is that cost measures the dollar value of any inputs used over any period to produce an item. But the "any inputs" portion of the statement is ambiguous. Therefore, inputs that do not result in actual dollar flows from the company can be considered costs. Employee time, for example, can be considered a cost to the company given this definition. This is an important consideration for determining research and development costs, since employees spend a great deal of time developing new products. When assessing the cost of a new product, managers typically try to recover development costs by allocating them to units of production. In many cases, these costs would have existed whether or not a new product was developed. Pricing should reflect the value the product creates for the consumer rather than the need to recover costs.

Costs are tied to dollar flows so that one can assess the actual effect of decisions and resulting costs on the bottom line of the company. This is important because decisions that deal with the use of one's time, for instance, might not have a bottom-line impact on the immediate performance of a company. Consider the engineer working on a design change made necessary due to a poor initial design. One might argue that it costs the company more money for an engineer to perform a design change. The input is increased because of the need for additional engineering work to be performed. However, the effect on the bottom line may actually be minimal or negligible. The company pays the engineer the same amount of money whether she is designing new products or performing an engineering change.

Another problem with the traditional definition is that tying costs only to producing an item is limiting. Office janitorial services, for example, have nothing to do directly with producing a product. Such costs exist regardless of the number of units produced. Allocating such costs, however, leads to a higher unit cost than if it were not allocated. This might have an impact on company performance, especially in markets where price elasticity of demand is prevalent.

Companies use various inputs to do business. Many of these inputs, such as rent and time-based salary, are independent of the actual number of units produced. A definition of costs should acknowledge that some costs exist that are independent of units. Such a definition could, if the true essence of the concept of cost is captured, open up a new space for understanding how to tie decisions directly to the bottom line through costs. Therefore, an alternative definition is proposed here: Costs measure the actual dollar flows from the company over a period of time as a result of the existence and operation of the business.

Cost types

The model presented here is based on the premise that costs have resource and activity components only. Resource costs are the costs that would be incurred if, hypothetically, no activities were performed. Salaries tied to time, for instance, are resource costs, as are rent payments and the utilities that must be paid to support the resources. These costs represent the resources of the company. Activity costs are those that increase as a result of performing an activity. Freight, production, and long-distance phone calls are examples of activity costs.

Considering these definitions, it is important to note two things: First, the definition of an activity cost here is somewhat different from that used in activity-based costing (ABC). Designing new products and the resources used in this process could be considered an activity in an ABC implementation. However, it is argued here that the resources are resources, not activities. Thus, ABC can include resources in its definition of an activity. This can lead to poor decisions.

Second, the model presented in this article does not use the traditional concepts of fixed and variable costs. All costs can and may vary, but they do so for many reasons other than production volume.

Resource costs

If a resource is at its maximum and additional resources are necessary to meet an increased demand, the total cost goes up upon the acquisition of additional resources. Likewise, when the capacity is such that there is a surplus, the elimination of resources lowers the capacity and reduces the total cost. For a company with one manufacturing plant, for example, the rent payments might remain the same whether the company produces no parts or 10,000 parts. If the demand requires the lease of additional plant space, however, the cost of rent goes up. The rent will stay the same until an expansion is required.

Examples of resource costs are salaries, buildings, machinery, and computer systems. These costs will change only with a change in resource levels by the cost of these resources. For example, a company can increase its human resource capacity by hiring more people. These costs, however, exist regardless of the production volume.

Activity costs

Activity costs are incurred by performing a particular activity. These costs may or may not be independent of the number of units produced. Production costs as an activity increase directly with increased production volume because there is a direct linear relationship between volume and non-scrapped materials. Machine set-up operations, where additional scrap might be produced in order to allow for steady-state operation prior to processing the scheduled parts, is independent of production volume. This cost is a function of the activity, not of the number of units produced. Therefore, the cost does not decrease as the number of items processed increases. The more setups, the higher the scrap cost, whether no products are processed during the production phase or an infinite number are processed.

Freight is an example of an activity cost. Assume that a manufacturing lot size is 100 units. Parts can be shipped individually or in any combination up to 100 units. Each time the company ships the parts, it incurs freight costs. The cost is a direct function of the activity of shipping and is only indirectly a function of the number of units produced.

Factor costs

Production costs that increase directly with increased production are called factor costs. Factor costs are generally — but not always — material costs. It is important to keep in mind that factor costs are actually a specific type of activity cost — those that increase as the number of units produced increases. Material costs will increase as the number of units produced increases. Four more tires are needed, for example, to produce the *n+1st* car. Labor paid by piecework is a factor cost; labor paid by the hour, week, month, or year is not.

Mixed costs

Some costs exhibit behavior that is similar to both factor and resource costs. An example is electricity. The cost to turn on the lights in the office is independent of the number of units produced and so could be considered a resource cost. However, if a machine is stamping fenders, the machine requires power to stamp the *n+1st* fender, which would not have been used had production stopped with the *nth* unit. Therefore, electricity can also behave as a factor cost; the difference is in the application. Since it is possible to determine the amount of electricity required to stamp the *n+1st* fender, one can also determine the electricity cost to stamp any fender. This value should be included in the unit factor cost. However, the cost to heat an office should be considered a resource cost, since the number of kilowatt-hours used exists independently of the number of products produced. Whereas traditional cost accounting would consider utilities mixed costs or semivariable osts, they can, in fact, be broken down into factor and resource components.

Mathematically, mixed costs can be expressed as

$$Mc = R_{mc} + F_{mc}U \qquad \textit{(Equation 1)}$$

where

$Mc \equiv$ mixed cost ($)
$R_{mc} \equiv$ resource portion of mixed cost ($)
$F_{mc} \equiv$ factor portion of mixed cost ($/unit)
$U \equiv$ units produced (units)

Therefore, to determine the factor cost for the *ith* item, one adds the material costs for the item to the factor portion for the same item, or,

$$Fc_i = F_{mc_i} + M_i \qquad \textit{(Equation 2)}$$

where

$Fc_i \equiv$ factor cost for the *ith* unit ($/unit)
$F_{mc_i} \equiv$ total mixed costs associated with producing the *ith* unit ($/unit)
$M_i \equiv$ material cost for the *ith* unit ($/unit)

Similarly, to determine the resource cost for the *jth* resource,

$$Rc_j = R_{mc_j} + R_j \qquad \textit{(Equation 3)}$$

where

$Rc_{j_{tot}}$ ≡ total resource cost for the *jth* resource ($)
R_{mc_j} ≡ total mixed cost portion of the *jth* resource ($)
R_j ≡ resource cost of the *jth* resource ($)

From here, the values can be inserted into the total cost equation as though they were material or labor costs.

Total cost

Total cost over a period of time is equal to the individual sums of resource costs, activity costs, and factor costs. In other words, total cost can be represented by the following relationship:

$$TC = \sum Rc + \sum Ac + \sum Fc \qquad \textit{(Equation 4)}$$

where

TC ≡ total cost
Rc ≡ resource cost
Ac ≡ activity cost
Fc ≡ factor cost

Noting that the activity cost for a particular activity (setups, for example) is shown as

$$Ac = \sum_i n_i Ac_i \qquad \textit{(Equation 5)}$$

where

n_i ≡ the number of times activity *i* occurs (occurrences/time period considered)
Ac_i ≡ the activity cost for activity *i* ($/occurrence)

and, similarly, that the factor cost or production of a particular item is

$$Fc = \sum_i Fc_i + U_i \qquad \textit{(Equation 6)}$$

where

Fc ≡ factor cost
Fc_i ≡ factor cost per each unit of product *i* ($/unit)
U_i ≡ the number of units of product *i* produced (units/time period considered)

the total cost is the sum of the resource costs, the activity cost multiplied by the number of times a particular activity occurs and the factor costs per unit multiplied by the number of units produced or,

$$TC = \sum_k (n_k \times Ac_k) + \sum_j Rc_j + \sum_i (Fc_i \times U_i) \qquad \textit{(Equation 7)}$$

where

i = 1,2,...,q the integer number of products manufactured
j = 1,2,…,r the integer number of resources with costs associated with them
k = 1,2,…,s the number of activities that occur
TC ≡ total cost (dollars/time period considered)
Ac_i ≡ the activity cost for activity *k* (dollars/occurrence)
n_k ≡ the number of times activity *k* occurs (occurrences/time period considered)
Rc_j ≡ the resource cost for resource *j* (dollars/time considered)
Fc_i ≡ factor cost per each unit of product *i* (dollars/unit)
U_i ≡ the number of units of product *i* produced (units/time period considered)

Notice that there is a total factor cost for a given product. However, this is the only cost that is directly attributable to the product. Activity costs are tied to the activities involved in the production process and the resource costs exist regardless. It is important to note that in each case, dollars are defined by explicit dollar flows.

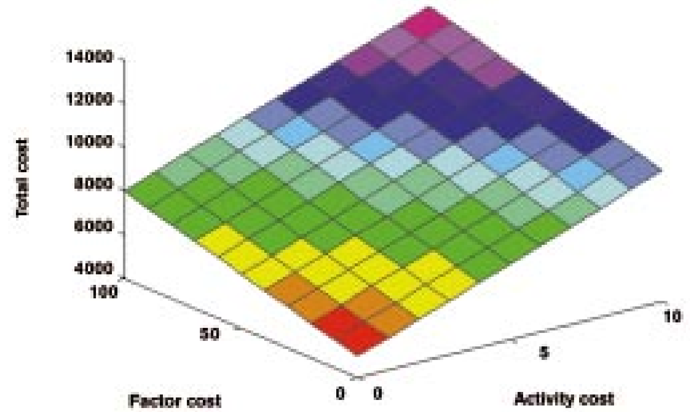


Figure 1. Total cost plane with resource costs equal to $5,000.

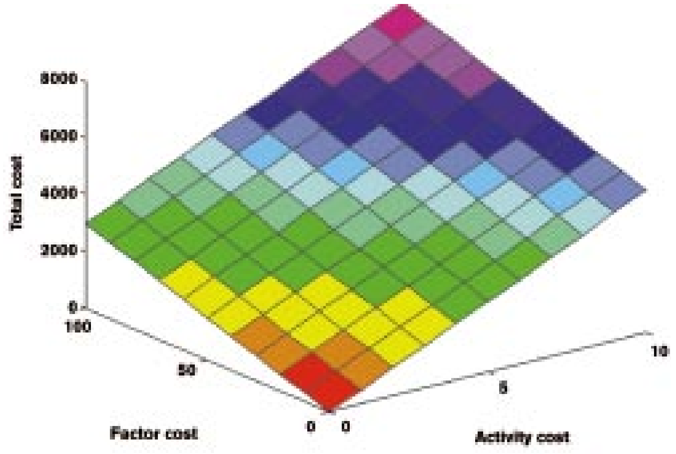


Figure 2. Total cost plane with no resource costs.

Lower cost on a curve	Lower cost surface
Fewer activities	Lower the cost per activity
Fewer units of production	Lower the factor cost per unit
	Lower the resource costs

Figure 3. The effects cost-cutting activities have on cost reduction.

Total cost surface

In a company where only one product is produced and only one activity is performed, Equation 7 creates a surface in a minimum four-dimensional space where along one axis are units, another axis activities, the third axis resources, and the last axis the magnitude of the cost. In the past, total cost has been depicted by a curve in two-dimensional space, with the axes being units as the abscissa and total cost as the ordinate. As the number of activities, products, and resources increase, the number of dimensions necessary to represent the surface increase. A company with two activities (shipping and long distance calls to one location) and two products (A and B) cannot be visualized because there are too many dimensions to represent. Therefore, the assumptions necessary to force costs into this curve eliminate too much information to allow for understanding and for decisions to be made. Activity costs, for example, are not recognized individually at all.

For the purposes of this argument, the axis representing resource costs will be represented by parallel surfaces rather than by its own axis because it is impossible to envision four-dimensional space. The change allows us to see the cost surface in three-dimensional space (Figure 1). Information is not lost, however, because one can picture different resource costs as parallel planes of increasing or decreasing total cost magnitude.

Dismissing a person, for instance, will shift the total cost curve down by the amount of the person's salary and the benefits paid for him. The other costs will remain the same as more units are produced or more activities are performed.

It is important to note that all terms are positive. This indicates that costs cannot go down with increasing production. One can reduce costs, as is shown in Figure 2, by reducing resource costs (reduce staff, sell plants, or move to a less expensive facility), activity costs (reduce the number of times an activity must occur, lower cost activities, require less scrap per setup), or factor costs (use different materials and suppliers). The cost function is monotonically increasing and will not go down as a function of anything, including increased operating efficiency.

Efficiency will not automatically decrease costs as more units or more jobs are produced because it is not a function of any of the above cost terms. In fact, increasing efficiency might increase total cost because the number of units produced can increase as a result. If everything were to stay the same, efficiency alone would lead to higher total costs. It can, however, put one on a lower cost plane as more efficient utilization of raw materials leads to lower material costs (Figure 3).

Conclusion

If managers desire bottom-line performance, the tools used to measure the effectiveness of decisions should tie the decision to factors that explicitly determine the bottom line. The model proposed in this article, when tied to decision making, will provide a more comprehensive understanding of the impact decisions will have on costs. Introducing activity and resource costs complicates the traditional understanding of costs by replacing the traditional cost equation and its two-dimensional graphic representation with a multivariable function represented as a multi-dimensional surface. However, the mathematical model introduced in this article is simple enough to not require graphical representation. Instead, by understanding how the variables in the equation behave, managers can create a reasonably accurate conceptual model of how decisions affect total costs and, therefore, the bottom line.

For Further Reading

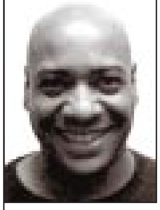
(See page 34 for ordering information)

Dolan, Robert J. and Hermann Simon, *Pricing Power: How Managing Price Transforms the Bottom Line,* The Free Press Inc., 1996.

Goldratt, Eliyahu M., *The Haystack Syndrome: Sifting Information Out of the Data Ocean,* North River Press Inc., 1990.

Hope, Tony and Jeremy Hope, *Transforming the Bottom Line: Managing Performance with the Real Numbers*, Harvard Business School Press, 1996.

The Author



Reginald Tomas Yu-Lee, Ph.D., is digital supply chain director at Sapient Corp., focusing on designing, developing, and implementing electronic business-to-business supply chain solutions. Prior to working at Sapient, he worked for many companies, including General Motors, IBM, Oracle, and Ernst and Young. Yu-Lee has a Ph.D. in engineering from the University of Dayton. His book, *Explicit Cost Dynamics: An Alternative to Activity Based Costing*, will be published by John Wiley and Sons in early 2001.