

Activity-Based Systems: Measuring the Costs of Resource Usage

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This paper describes the conceptual basis for the design and use of newly emerging activity-based cost (ABC) systems. Traditional cost systems use volume-driven allocation bases, such as direct labor dollars, machine hours, and sales dollars, to assign organizational expenses to individual products and customers. But many of the resource demands by individual products and customers are not proportional to the volume of units produced or sold.¹ Thus, conventional systems do not measure accurately the costs of resources used to design and produce products and to sell and deliver them to customers. Companies, including those with excellent traditional cost systems,² have developed activity-based cost systems so that they can directly link the costs of performing organizational activities to the products and customers for which these activities are performed.

I. ABC SYSTEMS AS RESOURCE USAGE MODELS

Activity-based cost systems estimate the cost of resources *used* in organizational processes to produce outputs.³ Many people have attempted to interpret activity-based costs using their more familiar fixed versus variable cost framework, an interpretation inconsistent with an ABC system's measurements of resource usage costs. The conventional fixed versus variable cost classification arises from an attempt to classify the likely change in spending or *supply* of a resource. The measurement of unused capacity provides the critical link between the costs of resources *used*, as measured by an ABC model, and the costs of resources *supplied* or *available*, as reported by the organization's periodic financial state-

ments.⁴ The following equation, defined for each major activity performed by the organization's resources, formalizes this relationship:

$$\text{Activity Availability} = \text{Activity Usage} \\ + \text{Unused Capacity}$$

A simple example illustrates the difference between the cost of resources supplied and the cost of resources used to perform activities.

¹Early versions of the transactional demand for resources appeared in J. Miller and T. Vollman, "The Hidden Factory," *Harvard Business Review* (September-October 1985), 142-150, and Robin Cooper and Robert S. Kaplan, "How Cost Accounting Systematically Distorts Product Costs," *Management Accounting* (April 1988), pp. 20-27. A more comprehensive explanation of the impact of diversity and complexity on indirect costs was presented in the series of *Journal of Cost Management* articles by Robin Cooper, "The Rise of Activity-Based Cost Systems: Parts I-IV" (Summer 1988, Fall 1988, Winter 1989, and Spring 1989).

²See, for example, Robert S. Kaplan, "John Deere Component Works (A) and (B)," HBS Cases # 9-187-107 and -108; Robin Cooper and Karen H. Wruck, "Siemens: Electric Motor Works (A)," HBS Case # 9-189-089.

³We will use the term "outputs" to refer generically to products, services, customers, projects, facilities or any object that creates a demand for or benefits from organizational activities. Activity-based cost systems assign the organization's operating expenses to outputs based on the activities performed for these outputs.

⁴We have adopted the terminology of unused capacity, as suggested by Alan Vercio of Texas Instruments, rather than our initial term of "excess capacity." Not all "unused" capacity represents "excess" capacity.

Many helpful and constructive comments on a previous draft were made by our colleagues including Anthony Atkinson, Toshiro Hiromoto, Jean-Francois Manzoni, Falconer Mitchell, Eric Noreen, Krishna Palepu, William Rotch, Keith Williams, and, especially, G. Peter Wilson.

Consider a purchasing department in which the equivalent of 10 full-time people [the *resource supplied*] are committed to processing purchase orders [the *activity performed*]. If the monthly cost of a full-time employee is \$2,500,⁵ the monthly cost of the activity, "Process Purchase Orders," equals \$25,000. Assume that each employee, working at practical capacity, can process 125 purchase orders per month, leading to an estimated cost of \$20 for processing each purchase order.⁶ Thus, the organization, each month, spends \$25,000. This expenditure provides a capability to process up to 1,250 purchase orders [the *activity availability*] during the month. During any particular month, the department may be asked to process fewer purchase orders, say only 1,000. At an estimated cost of \$20/purchase order, the ABC system would assign \$20,000 of expenses to the parts and materials ordered by the purchasing department that month. The remaining \$5,000 of monthly operating expenses represents the cost of unused capacity in the purchase order processing activity.

This example shows why companies need two different reporting systems. The periodic financial statements provide information on the cost of activities supplied each period (the \$25,000 monthly expense in the purchasing department); and the activity-based cost system provides information on the quantity (1,000 purchase orders) and the estimated cost (\$20,000) of activities actually used in a period. The difference (\$5,000) between the cost of activities supplied (\$25,000) and the cost of activities used (\$20,000) equals the cost of unused capacity (or capacity shortage) during the period. And this difference is measured for each organizational activity, defined by the ABC system.⁷

The two systems provide different types of information for management. The cost of resources supplied is relevant for predicting near-term spending. Spending on many organizational resources will not vary with short-term fluctuations in activity volume and mix. That is why these costs have been classified as "fixed" in numerous accounting systems and textbooks.

But measuring and managing the operating expenses of most organizational resources as fixed in the short-run does not give much insight as to why the resources were acquired, what the resources are currently being used for, and the level of resources that will likely be required in the future. While the cost of supplying the resources may be fixed in the short-run,⁸ the quantity of these resources used each period fluctuates based on activities performed for the outputs produced. Activity-based systems measure the cost of using these resources, even though the cost of supplying them will not vary, in the short run, with usage.

The ABC resource usage cost information can be used by managers to monitor and predict the changes in demands for activities as a function of changes in output volume and mix, process changes and improvements, introduction of new technology, and changes in product and process design. As such changes are contemplated, managers can predict where either shortages or excesses of capacity will occur. The managers can then either modify their decisions so that activity demand will be brought into balance with activity supply, or they can change the level of activities to be supplied in forthcoming periods.

For example, if newly designed custom products, with many unique parts and materials, are added to the mix, managers may forecast a much higher demand for the purchasing activity, perhaps now requiring that 2,000 purchase orders a month be processed. With no change in the process or efficiency of the processing purchasing order activity, this increase in demand will exceed available sup-

⁵This cost includes the costs of fringe benefits, secretarial and administrative support, equipment costs, and space charges associated with each purchasing department employee.

⁶Note that this calculation does not use actual activity levels during the period; the denominator represents service capacity not actual usage of this capacity.

⁷Later in the paper, we will show how to develop a new format for the periodic income or expense statement that highlights the costs of resources used and unused.

⁸More accurately, the spending on (or expenses assigned to) these resources will be independent of the volume and mix of outputs produced during the period.

ply by 750 purchase orders per month, a shortage that can be relieved by hiring six more purchasing clerks. The ABC model, in addition, will trace purchasing costs directly to the newly designed custom products that are creating the demand for these additional purchasing resources, enabling managers to determine whether the revenues received fully compensate the organization for the cost of all the resources used to produce and deliver these products.

Of course, supplying additional purchasing clerks is only one possible action that the managers can take to the contemplated activity shortage. The engineering department can be asked to redesign the custom products so that they make more use of existing part numbers, an action that would reduce the amount of additional purchase orders required. Or the managers can search for process improvements or technology that would make the purchase order processing activity more efficient, perhaps raising the monthly output per person from 125 to 200 purchase orders.

Thus, measuring the *costs of resources supplied* indicates to managers the level of current spending (or, more generally, expenses) and the capacity to perform activities that this spending has provided. Measuring the *costs of resources used* by individual outputs provides information for managerial actions, as will be discussed more fully subsequently in the paper.

II. ISN'T THE UNUSED CAPACITY CALCULATION JUST A NEW NAME FOR THE VOLUME VARIANCE?

The calculation of unused capacity each period looks, at first glance, suspiciously like the traditional cost accounting volume variance. But the formulas:

$$\begin{array}{l} \text{Activity Availability} = \text{Activity Usage} \\ \quad \quad \quad \quad \quad \quad \quad \quad + \text{Unused Capacity} \\ \text{or} \\ \text{Cost of Activity Supplied} = \text{Cost of Activity Used} + \text{Cost of Unused Activity} \end{array}$$

differ from the standard cost calculations of a volume variance in several significant ways.

First, and most obviously, volume variances are reported only in aggregate financial terms since traditional cost systems do not identify the **quantity** of overhead resources supplied or used. The activity-based approach reports both the quantity (number of purchase orders not written) and the cost of unused capacity. Second, traditional volume variances are often calculated with a denominator volume based on budgeted production, rather than practical capacity. In the activity-based approach, the "denominator volume" must always be the practical capacity of the activity being supplied, not the anticipated volume. And, third, the traditional cost accounting procedure of allocating overhead with a denominator volume is viewed as useful only for inventory valuation, not to provide information relevant for management; e.g.,

The preselected production volume level of the application base used to set a budgeted *fixed-factory-overhead rate for applying costs to inventory* is called the denominator volume.

In summary, the production volume variance arises because the actual production volume level achieved usually does not coincide with the production level used as a denominator volume for computing a budgeted application rate for *inventory costing of fixed-factory overhead*.⁹ (emphasis added)

Note how students are instructed that the calculation involves only the application of (so-called) *fixed-factory overhead* to units of production. Clearly, the volume variance is viewed, at least in textbooks (but not always in practice), as a cost accounting exercise for financial statements that is devoid of managerial significance.

These three differences between volume variances and measurements of unused capacity, while real, are not, however, the most important distinction. The cost accounting calculation that leads to a volume variance uses a measure of activity volume for the period (i.e., the denominator volume, also called the allocation base) that varies with the number of units produced. Direct labor hours, units of

⁹Charles T. Horngren and George Foster, *Cost Accounting: A Managerial Emphasis, Seventh Edition* (Prentice-Hall, 1991), pages 258 and 265.

production, materials purchases, and machine hours are typical allocation bases used by traditional systems to assign factory expenses to products in production cost centers.¹⁰ Implicitly, this procedure assumes that factory expenses are used by products in proportion to the overhead allocation base, i.e., proportional to volume of units produced. In practice, of course, this assumption is not valid.

Activity-based cost systems use separate activity cost drivers (the ABC generalization of an assignment or allocation base) for each activity. The activity cost drivers are not devices to allocate costs. They represent the demand that outputs make on each activity. For example, the activity cost driver for the setup activity could be the number of setups or the number of setup hours; the activity cost driver for processing purchase orders could be the number of purchase orders; the cost driver for administering and maintaining parts in the system could be the number of active part numbers. While some activity cost drivers are unit-related (such as machine and labor hours), as conventionally assumed, many activity cost drivers are batch-related, order-related, product-sustaining, and customer-sustaining.¹¹

Because traditional cost systems use allocation bases that do not represent the demands for support resources by activities, the volume variance for a period can be zero even while substantial shortages or surpluses of capacity exist for many individual activities. For example, if actual production includes an unexpectedly high proportion of mature, standard products, produced in large batches, the demands for many batch and product-sustaining activities will be well below the quantity of resources supplied to perform these activities and much unused capacity will exist during the period. Conversely, if the actual production volume includes a substantial and unexpectedly high number of new, customized products, that are made in very small batches, the demand for batch and product-sustaining activities may exceed the quantity supplied. Shortages, delays, and overtime may occur in the batch and product-sustaining activities even though the total quantity of units pro-

duced during the period equaled the budgeted or anticipated amount.

The distinction between the measurement, by activity-based cost systems, of the cost of activities used (and unused) and the traditional cost accounting emphasis on fixed versus variable costs can be reconciled by examining closely the way managers contract for and supply resources to perform organizational activities.

III. RESOURCES THAT ARE SUPPLIED AS USED (AND NEEDED)

Some resources are acquired as needed. For these resources, the cost of resources supplied will generally equal the cost of resources used. For example, materials are usually ordered as needed so that materials expense equals the cost of materials used. And the cost of energy supplied to operate production machines also equals the cost of using that energy. Temporary employees hired on a daily basis from employment agencies and employees who are paid on a piece-work or overtime basis are additional examples. The company contracts with these workers to produce output and the workers are paid only when they are needed to produce output. Capital supplied by lenders is another example where the supply and the usage cost are identical (equaling the interest expense on the amount borrowed).¹²

In general, when the organization acquires a resource from outside suppliers, without long-term commitments, the cost of using the

¹⁰More complex traditional systems that use multiple allocation bases within the same cost center will have multiple volume variances, but each allocation base is still unit-level, driven by the volume of output.

¹¹The hierarchy of factory expenses was introduced in Robin Cooper, "Cost Classification in Unit-Based and Activity-Based Manufacturing Cost Systems" (Fall 1990), pp. 4-13, and discussed further in Robin Cooper and Robert S. Kaplan, "Profit Priorities from Activity Based Costing," *Harvard Business Review* (May-June 1991), pp. 130-137.

¹²Of course, the commitment fee associated with a line of credit is a counter-example, because the cost of supplying the resource (the right to borrow) is incurred whether the resource is used or not.

resource can equal the cost of acquiring (and supplying) the resource; for example, when the organization acquires the resource in spot markets. The costs of supplying such resources are apparently what many people have in mind when they refer to "variable costs." Such resources have no unused capacity. Whatever is supplied is used, or, alternatively, whatever is needed is acquired. This causes the costs of supplying the resource to be strongly correlated with the quantity (and hence the cost) of the resource used.

IV. RESOURCES THAT ARE SUPPLIED IN ADVANCE OF USAGE

Organizations commit, however, to making many other resources available whether or not the resources will be fully used for current and future activities. This commitment can take several forms. The organization can make a cash expenditure to acquire a resource that provides service for several periods into the future. The most common example occurs when the company acquires or overhauls buildings and equipment. Such a transaction leads to an expense being recognized in each period during the useful life of the resource, with the organization gaining the capacity provided by the resource during each such period. The expense of supplying the resource will be incurred, each period, independent of how much of the resource is used.¹³

As a second example, the organization can enter into an explicit contract to obtain the use of a resource for several periods in the future. For example, a company leases buildings and equipment, or it guarantees access to energy or key materials through take-or-pay contracts. In this situation, a cash payment will occur and an expense will be recognized in each future period. Again, the amount of the cash payment and associated expense are independent of the actual quantity of usage of the resource in any period.

The third, and most important, example occurs when an organization enters into implicit contracts, particularly with its salaried and hourly employees, to maintain employment levels despite short-term downturns in

activity levels. In this case, the spending (and expenses) associated with these employees will remain constant independent of the quantity of work performed by the employees.¹⁴

In each of the three contracting mechanisms, the organization acquires units of service capacity before the actual demands for the service units are realized. Consequently, the expenses of supplying the service capacity from these resources are incurred (or recognized) independent of usage. This independence in the short-run between the supply (or expense) of these resources and their usage has led this category of expense to be considered "fixed" with respect to current production volume and mix.

The separation between the acquisition of resource capacity and its actual usage arises from economies-of-scale in contracting for resources. For example, some service units come in lumpy amounts (e.g., physical capacity of machines, or the services provided by individual employees). Managers also find it less expensive to acquire some resources on a long-term commitment basis rather than to contract continually in spot markets to acquire resource capacity as needed.¹⁵ These issues

¹³We are using the word "expense" in its traditional accounting sense; e.g., an outflow or other using up of assets or incurrence of liabilities (or a combination of both) during a period from delivering or producing goods, rendering services, or carrying out other activities that constitute an enterprise's ongoing major or central operations (W. W. Cooper and Yuji Ijiri, *Kohler's Dictionary for Accountants, Sixth Edition* (Prentice-Hall: Englewood Cliffs, NJ, 1983; pp. 203-204). To avoid confusion associated with financial accounting inventory valuation procedures that shift some period expenses forward in time to be matched against future revenues generated, we will assume, for purposes of this paper and without loss of generality, that units produced always equal units sold. This enables all period expenses to be recognized as expenses in the period they are incurred.

¹⁴The actual expenses of providing this capability in a given period can even exceed the cash outlays in that period. This situation arises when cash payments made in much later periods, such as for vacations, pensions and other post-employment benefits, are attributed to the supply of the resource during the given period.

¹⁵This prior commitment can also be made for strategic reasons; see Pankaj Ghemawat, *Commitment: The Dynamic of Strategy* (Free Press, 1991).

have been discussed at some length by scholars, such as Coase, Chandler, and Williamson.

Through any or all of these three contracting mechanisms, the organization acquires a capability or capacity to perform activities, and an associated expense of providing that capacity. The first step, therefore, in an activity-based analysis is to estimate both the expense of providing the capacity to perform an activity (the \$25,000 monthly expense to process purchase orders), and the capacity or number of units of service activity that can be practically delivered (the 1,250 purchase orders per month) by the resources supplied. The expense of providing the activity capacity is divided by the number of available service units to obtain an estimate of the cost of supplying a unit of service of the activity (the \$20 per purchase order cost).

V. MEASURING COSTS OF RESOURCES USED IN A PERIOD: THE ROLE FOR ACTIVITY-BASED COST SYSTEMS

The distinction between resources supplied as needed and resources supplied prior to (but in anticipation of) usage suggests that a relatively simple system can be used for the periodic measurement of actual expenses (see Exhibit 1). In this system, short-term contribution margin is measured as price (or revenues) less the cost of resources acquired as needed: materials, energy, and short-term labor (and overtime). By assumption, the remaining operating expenses represent resources that have been acquired prior to actual usage. The costs of these resources should be unaffected by actual activity levels during the period. The periodic income statement can report, for each activity, the costs of resources used for outputs and the costs of resources unused during the period.

For management purposes, flexible budgets and variance analysis become unnecessary for these expense accounts. A simple comparison of actual to budgeted expenses, account by account, will suffice to provide feedback.¹⁶ Basically, the authorized expenses have been determined either by prior commit-

ments (acquiring plant, property, and equipment; signing take-or-pay contracts) or during the annual budgeting process. One manufacturing manager expressed this point quite forcefully:

Cost variances are useless to me. I don't want to ever have to look at a cost variance, monthly or weekly. Once you've decided to run a product, you don't have many choices left. Resources are already committed regardless of how the cost system computes costs among alternative processes.

Monthly, I do look at the financial reports. ... I look closely at my fixed expenses and compare these to the budgets, especially on discretionary items like travel and maintenance. I also watch headcount. But the financial systems still don't tell me where I am wasting money. I expect that if I make operating improvements, costs should go down, but I don't worry about the linkage too much. The organizational dynamics make it difficult to link cause and effect precisely.¹⁷

Managers may be encouraged to modify their use of resources in the short-run based on information on unused capacity. For example, when excess setup capacity exists, they can temporarily decrease batch sizes. Alternatively, managers may be expected to adjust downward the quantity of resources supplied when substantial amounts of unused capacity persist for several periods.

Several organizations, however, not understanding the important distinction between measuring the costs of resources supplied (and expensed) and the costs of resources used, have attempted to use their activity-based systems to budget monthly expenses. A good example of the problems arising from using

¹⁶This distinction between the financial system required for periodic performance measurement (reporting on actual period expenses) and the activity-based system reporting on the costs of resource usage underlay the arguments in R. S. Kaplan, "One Cost System Isn't Enough," *Harvard Business Review* (January-February 1988). A good example of a company that separated its monthly reporting system from the system used to estimate the cost and profitability of its products is provided by the Union Pacific case study described in the Appendix.

¹⁷Quote taken from Robert S. Kaplan, "Analog Devices: The Half-Life System," HBS # 9-190-061.

EXHIBIT 1
Example of ABC Income Statement

SALES			<u>20,000</u>
Less: EXPENSES OF RESOURCES SUPPLIED AS USED			
Materials	7,600		
Energy	600		
Short-term labor	900		
			<u>9,100</u>
CONTRIBUTION MARGIN			<u>10,900</u>
Less: ACTIVITY EXPENSES: COMMITTED RESOURCES	<u>Used</u>	<u>Unused</u>	
Permanent direct labor	1,400	200	
Machine run-time	3,200		
Purchasing	700	100	
Receiving/Inventory	450	50	
Production runs	1,000	100	
Customer administration	700	200	
Engineering changes	800	(100)	
Parts administration	750	150	
TOTAL EXPENSES OF COMMITTED RESOURCES	<u>9,000</u>	<u>700</u>	<u>9,700</u>
OPERATING PROFIT			<u>1,200</u>

an activity-based system for monthly performance measurement was documented in the Hewlett Packard: Queensferry Telecommunications Division case.

Hewlett Packard: QTD Case¹⁸

QTD had recently installed a new activity-based cost system. The system accumulated expenses at each process and assigned these expenses to products with a cost driver defined for each process (e.g., number of axial insertions). The system was developed primarily to provide process cost information to product engineers to help them design products that would be less expensive to manufacture. The system, however, was also used to monitor production performance. The two functions soon came into conflict when production volume dropped due to the postponement of a major contract. The lower production volume led to large monthly volume variances because operating expenses could not be reduced proportionately to the decline in volume. The controller commented:

In a perfect world, spending would drop to offset lower production volumes. However, in environments like ours, where we retain our employees, it is almost impossible for spend-

ing to be cut back when volume drops in a period.

Higher cost driver rates were calculated, based on the lower production volumes, so that the accounts would "clear" each period without large volume variances. This change, however, negated the primary purpose of the newly designed system. With unused capacity expenses now loaded on to cost driver rates, the system no longer provided product designers with accurate information on the expenses of activities performed to manufacture their products.

Companies like QTD, that attempt to budget expenses each month from their activity-based resource usage model, will end up, each month, with a variance representing the unused capacity for every activity and resource for which usage and availability are not perfectly correlated. The unused capacity variance signals only that managers did not adjust the resource availability level to the amount actually required for the volume and mix of outputs produced that period. It is not

¹⁸Robin Cooper and Kiran Verma, "Hewlett Packard: Queensferry Telecommunications Division," HBS Case # 9-191-067.

helpful, however, to predict spending or expense changes.

Once decisions get made on resource availability levels in the organization, typically in the annual budgeting and authorization process, the expenses of supplying most resources will be determined for the year (unless managers deliberately act to eliminate or add to the resources). For example, the resources committed to the purchase-order processing activity will be determined annually as a function of the expected number and complexity of purchase orders to be processed. We would *not* expect, however, the size of the purchasing department to fluctuate weekly or monthly depending on how many purchase orders get processed during a week or a month. Therefore, even when usage of a resource drops, the expense associated with that resource continues at its previous level. The difference between the costs of resources supplied and the costs of resources used for producing products equals the cost of **unused capacity** for the period.¹⁹ The difference should not be interpreted as a change in the cost of performing the activity.

VI. RELEVANCE FOR MANAGERIAL DECISIONS: USING ABC TO INCREASE PROFITS

An improved costing system is a means to an end. The goal is to increase profits, not to obtain more accurate costs. How do activity-based cost systems help companies improve their profitability? We attempt to answer this question through the simple profit equation:

$$\text{Profits} = \text{Revenues} - \text{Expenses}$$

Pricing and Product Mix

Some companies use their ABC information to reprice their products, services, or customers so that the revenues (resources) received exceed the costs of resources used to produce products for individual customers. For example, prices are lowered to customers ordering standard products in high volumes, and prices are raised to customers ordering highly customized products in low volumes. Pricing strategies are part of a broader set of actions

taken by managers to improve profits through changes in product and customer mix. For example, some companies, experiencing declining demand for their standard products, proliferated their product line to offer customized, low-volume varieties. This strategy was influenced by their belief that many costs were "fixed" and that the lost volume in standard products needed to be replaced with customized products that could "absorb overhead" and even sell at price premiums. With this traditional view, the labor hours, machine hours, and materials purchases could be approximately the same between the old product and the new product mix. But the new product mix included many customized, low volume products that made many more demands on resources performing batch and product-sustaining activities. Because sufficient unused capacity did not exist to perform these activities, the companies had to increase their spending so that more resources could be supplied to perform batch and product-sustaining activities. After the product proliferation had occurred, and the companies were incurring higher expenses for support resources, ABC models revealed that many of the newly-added products were unprofitable.²⁰

Once this situation has been discovered, managers have typically first attempted to raise prices on the unprofitable products. If this action does not generate sufficient revenues to cover all their product-specific costs, managers contemplate eliminating unprofitable products. Or they consider outsourcing products to suppliers whose total cost of acquisition is below the cost of resources required to make the product internally. Of course, before outsourcing or dropping products, managers should verify that they can eliminate the resources no longer needed or can replace the lost volume with more profitable business. Thus before any decision is taken from activity-based product or customer

¹⁹During a period when usage exceeds normal capacity, the difference will represent a "favorable" over-utilization of capacity.

²⁰Unprofitable products are those for which the expenses assigned to maintain, produce, and deliver them exceed the net revenues received from their sale.

costs, managers must assess the incremental revenue and spending consequences.

Critics of ABC have stated:

Isn't this what we have been teaching (or practicing) as relevant costing or incremental analysis? Students in introductory cost and managerial accounting classes are already taught that costs unaffected by whether a particular product is retained or eliminated are irrelevant for that decision and should be excluded from the analysis. Why do companies need an ABC system? Why not just calculate the changes in spending that would occur for any contemplated decision, such as dropping or outsourcing a product, and make a decision based on that analysis? What purpose is served by building, maintaining, and attempting to interpret a generalized activity-based cost model?

Perhaps one can understand the demand for a generalized (activity-based) resource usage model from a similar situation that arises in physics. Introductory physics courses teach Newton's laws of motion, such as conservation of angular momentum or gravitational attraction. The principles are illustrated with problems that require calculating the interactions among two or three objects. Students who survive to more advanced physics courses encounter a subject called statistical thermodynamics, which provides predictions of the aggregate behaviors of large numbers of particles. A naive student might ask, "Why do we need to study thermodynamics as a separate subject? Don't Newton's laws of motion still apply to these particles?" The answer is, of course, they do, but to apply Newton's laws to the large numbers of particles being studied would exceed the lifetime and computational power of the universe. Therefore, physicists have devised laws to describe and predict the aggregate behavior of large numbers of interacting particles.

"Relevant costing" or "incremental analysis" situations are illustrated in introductory courses and books by simple examples with two or three products and simple overhead structures. An activity-based resource usage model can be viewed as the thermodynamic equivalent to the three product examples of introductory cost accounting courses. Consider, for example, the analysis that arises in the Bridgeton Industries case.²¹ The plant ini-

tially produced five product lines. Because of competitive pressures, the plant's profitability had declined. Special studies were performed and eventually two product lines were outsourced. As the case proceeds, students learn that the total spending on resources declined by less than the loss in revenues so that the economics of the plant had deteriorated further. From a "relevant costing" perspective, how many special analyses would have been required to determine which product lines or combinations of product lines should have been dropped. Certainly each product line individually could have been analyzed. But because most resources come in lumpy amounts, perhaps substantial reductions in resource supply (and therefore spending) would occur only if at least two product lines were dropped, as was actually done. But why stop at two? Why not consider dropping all combinations of three, or four, or even all five product lines? In total, 2⁵ or 32 combinations would have to be analyzed, with the relevant costs calculated for each of the 32 possible maintain/drop combinations.

The 32 possibilities may not seem insuperable, but for companies with hundreds and thousands of products, customers, processes, and facilities, the combinations, while still finite, would, as in thermodynamics, exceed the lifetime and computational power of the universe to enumerate much less evaluate. And retain versus drop is a relatively simple binary decision. What about shifts in product mix, improvements in production processes, and changes in product designs? Managers cannot possibly apply introductory cost accounting relevant cost calculations to all possible product and customer mix decisions. The activity-based cost model, like the thermodynamics model, provides an aggregate view of the economic laws of motion of a complex enterprise, with thousands of individual products, customers, and facilities.²²

²¹Robin Cooper, "Bridgeton Industries: Automotive Component and Fabrication Plant," HBS Case # 9-190-085.

²²And even the thermodynamic extension is now known to be an approximation that ignores relativistic and quantum mechanical phenomena. Similarly, the activity-based resource usage model, as currently formulated, is likely just a first order, linear approximation to what may require stochastic, nonlinear formulations in certain situations.

Borrowing another analogy, integral calculus teaches us that the sum total of doing lots of little things can amount to something substantial. An activity-based resource usage model forecasts the changes in aggregate demands for activities from making decisions on many products, services, and customers. In effect, the activity-based cost model performs the integral calculus function of adding up a lot of small effects into something quite substantial. It approximates the changes in resource demands that will occur from implementing new decisions on pricing, product mix, and customer mix. Before actually implementing the proposed decisions, of course, managers must assess the cash flow consequences by forecasting, as well, the increases and decreases in resource supply (including revenues) that they anticipate will occur. An activity-based cost model serves to direct managers' attention to where more detailed analysis will likely yield the highest payoffs. The ABC model reduces the dimensionality of decisions to where the cash flow consequences from only a few alternatives need to be examined closely.

Change Resource Usage

In addition to pricing, product and customer mix changes, which affect profits directly through changes in the margins earned between revenues received and resources expended, ABC models can help managers reduce resource usage, while holding revenues constant. When resource usage is reduced, some unused capacity will be created which can then be either managed away (enabling lower spending to occur) or used to process more throughput (enabling more revenues to be earned). Demands on support resources can be reduced by taking two types of actions:

- Reducing the number of times activities are performed, and
- Increasing the efficiency with which activities are performed.²³

Reducing number of times activities are performed:

Changing from unprofitable to profitable product and customer mixes, as described

above, enables companies to earn the same or even higher revenues while performing fewer activities. Managers can take additional actions to reduce the number of times activities are performed, especially activities performed by support resources. Marketing and sales executives in some companies have set *minimum order sizes* to reduce the large number of activities triggered by many small orders. As engineers *improve the design of products*, fewer engineering change notices are required. Other change activities are reduced when engineering managers discourage their employees from excessive tinkering with existing product designs, and marketing managers discourage or *charge premiums for customer-requested changes* in products and delivery schedules. In addition, design engineers, informed about the resource expenses associated with introducing and maintaining a large number of parts in the system, can develop product designs that use *fewer and more common parts*.²⁴ All these actions, individually and in combination, reduce the number of demands for activities performed by support resources, while maintaining existing (unit-driven) production volume.

*Increasing efficiency (lowering the cost) of activities performed:*²⁵

A complementary set of actions can be taken to increase the efficiency of performing activities. The increased efficiency enables the same *quantity* of activities to be performed with fewer resources. Continuous improve-

²³These actions are iterative, not sequential, as managers continually adjust the volume and mix of their outputs, and manage the efficiency with which their activities are performed.

²⁴These design activities were the focus of the ABC systems described in the Tektronix and Hewlett Packard cases: Robin Cooper and Peter Turney, "Tektronix (A)," HBS Case # 9-188-143; and "Hewlett-Packard Roseville Networks Division," HBS Case # 9-189-117.

²⁵Using activity-based information to focus improvement activities was discussed in H. Thomas Johnson, "Activity-Based Information: A Blueprint for World-Class Management Accounting," *Management Accounting* (June 1988), pp. 23-30. Using an activity-based cost system for performance improvement was a central focus in the system described in Robert S. Kaplan, "Maxwell Appliance Controls," HBS Case # 9-192-058.

ment programs, such as *total quality management* and *cycle time reduction* (just-in-time), reduce the resources required to inspect products, changeover and setup machines, and move and store materials. Successful implementation of continuous improvement programs produces major reductions in the demands for resources to perform batch and product-sustaining activities.

Introduction of advanced *information technology* reduces by substantial amounts the expenses of many batch and product-sustaining activities. Computer-Aided-Design and Engineering (CAD/CAE) equipment reduces the expenses of designing products and making changes to existing products. They also standardize the maintenance of routings and bills-of-materials. Flexible Manufacturing Systems (FMS) and Computer Integrated Manufacturing (CIM) essentially eliminate many batch activities through automatic scheduling, materials movement, inspection, and tool positioning, gauging, and maintenance, plus instantaneous changeovers between operations. In the theoretical limit, a CIM system requires the same resources to make 1 unit of 1,000 different products as it does to make 1,000 units of 1 product.²⁶ Electronic Data Interchange (EDI) and Electronic Funds Transfer (EFT) link companies with suppliers and customers, greatly reducing the expenses associated with purchasing, scheduling, receiving, shipping, invoicing, and paying for materials and products.

Improving Profits

Through a combination of reducing the quantity of activities performed and increasing the efficiency of performing the remaining activities, companies can maintain production throughput and, hence, revenues while reducing their demands for indirect and support resources. Ideally, managers can now obtain additional business, many of whose demands would be handled by resources currently in excess supply. This would enable the company to enjoy substantially higher profits because revenues would increase with only modest spending increases.²⁷ Alternatively,

the unused capacity created can be reduced in the next budgeting cycle.

Budgeting: Changing the Supply of Resources to Match Resource Demands

As managers adjust their product and customer mixes, introduce new products, phase out mature products, improve operating processes, and introduce new technology, they change the demands for activities performed by indirect and support resources. The revised demands for resources to perform support activities can be estimated with an activity-based model. Differences between the demand for and the supply of resources can then be translated into expected changes in future spending on resources. Used in this way, the activity-based model becomes a central tool for management planning and budgeting. The budgets for each resource are determined based on the activities required for the forecasted product volume and mix, and existing production processes. For resources forecasted to be in short supply, the analysis provides a justification for additional spending to increase resource availability. For a resource forecasted to be in excess of predicted demands, managers can be requested to reduce the availability and hence the expenses of that resource. They can reduce the unused capacity by selling or scrapping machinery without replacement, by not replacing employees who retire or leave the organization voluntarily, by redeploying employees from activities where they are no longer needed to activities where capacity shortages exist, or, more drastically, by laying off now redundant employees. These actions enable the company to generate the same revenues with fewer resources, thereby allowing profits to increase.

²⁶In effect, CIM transforms batch and product-sustaining activities into unit-level activities so that product variety costs approach zero.

²⁷Spending will increase for resources for which availability and usage are tightly coupled (e.g., materials, energy), and for resources where unused capacity does not exist (perhaps direct labor or machine time). Also, it would be preferable for the added volume to generate revenues in excess of the expenses of resources used so that the new business can be sustained in the long run.

Alternatively, companies may not exploit the profit opportunities from having created unused capacity. They may keep existing resources in place, even though the demands for the activities performed by the resources have diminished substantially. In this case, and only in this case, will the actions that reduced activity usage not yield any tangible benefits. Profits will remain the same, since revenues have remained constant and the expenses of resources supplied have also remained fixed. But the failure to increase profits is not due to costs being intrinsically "fixed." Rather, the failure is the consequence of managers being unable or unwilling to exploit the unused capacity they have created. The activity-based cost model focuses managers' attention on decisions that affect the resource demands by activities. If the decisions lead to lower demands for some resources, the company can then realize increased profits by either using these resources to generate higher revenues or by reducing spending on these resources. The costs of these resources are only "fixed" if managers cannot or do not exploit the opportunities from the unused capacity they helped to create.

VII. SUMMARY AND CONCLUSIONS

Activity-based cost systems contain two important insights. First, the activities performed by many resources are not demanded in proportion to the total volume of units produced (or sold). The demands arise from the diversity and complexity of the product and customer mix.

Second, activity-based cost systems are not models of how expenses or spending vary in the short-run. ABC systems estimate the costs of resources used to perform activities for various outputs. During any given period, the production of products and services, and their marketing, sale, and delivery to customers, create a demand for organizational activities. The quantity of each activity supplied to outputs is estimated by activity cost drivers such as the number of setup hours, number of purchase orders processed, number of receipts, number of direct labor and machine hours, and number of parts maintained. By summing across the costs of all resources supplied to perform activities for individual outputs, the ABC model estimates the costs of resources used during the period by all the organization's outputs.

Activity-based systems model how activity usage varies with the demands made for these activities. If activity usage exceeds the quantity available from existing resource supply, then higher spending to increase the supply of resources will likely soon occur. If, however, activity usage is below available supply, spending or the expenses of resources will not decrease automatically. Management, to obtain higher profits, must take conscious actions either to use the available capacity to support a higher volume of business (i.e., by increasing revenues) or to reduce spending on resources by eliminating the unused capacity. Costs and profits are fixed only if management takes no action, and leaves the unused capacity undisturbed. Management behavior, not cost behavior, determines whether reductions in resource demands become translated into higher profits.