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Evaluating The Economics Of Short- And Long-Run Production-Related Decisions*

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The role of activity-based costing (ABC), like any accounting system, is to provide information for assessing the economic consequences of resource allocation decisions. The primary focus of ABC involves measuring the cost of the resources used to produce a firm's products (Cooper and Kaplan, 1992). This is accomplished by treating the cost of an activity's resources as proportional to the capacity of the services it provides. The cost of an activity's resources is then traced to products based on the quantity of its services used in a product's production. ABC reflects a long-run perspective of production, in which the cost of labor and overhead resources is a variable cost. However, many of the firm's labor and overhead resources are contracted in advance of usage, such as rent on factory equipment, or influenced by management policies, such as retaining workers in periods of excess labor capacity. Equally important, in the short run, the capacity of the firm's support and production activities is limited. Therefore, when the demand for an activity's service exceeds its supply, a bottleneck is created that restricts the firm's production and creates an opportunity cost that affects the economics of production-related decisions. However, ABC ignores constrained activities and the opportunity cost of using these activities' resources in the firm's operations. ABC's failure to reflect the cost of resources that are fixed and to incorporate the effect of constrained activities in the short run led Theeuwes and Adriaansen (1994) to state that ABC is unsuitable for operational decision making.

The deficiencies of ABC led Bakke and Hellberg (1991) to propose using the theory of constraints (TOC) for making short-run resource allocation decisions. Conversely, Woods (1992) and Christensen and Sharp (1993) proposed modifying ABC to reflect the short-run variable and fixed costs of a firm's resources. Sim-

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ilarly, Kaplan and Atkinson (1998) suggested that an activity's cost may be separated into its short-run flexible and committed components. This enables ABC to measure the incremental cost of resources used by products, customers, or other objects of interest in the near term. However, short-run decisions made with the TOC and modified ABC models are problematic. The TOC incorporates only direct materials as a variable cost. However, even in the shortest of time horizons, some labor and overhead resources, such as temporary workers, power, and supplies, are a variable cost. Therefore, the TOC may underestimate the cost of a product and may lead to suboptimal resource allocation decisions. The modification of ABC proposed by Woods (1992), Christensen and Sharp (1993), and Kaplan and Atkinson (1998) ignores constrained activities that restrict the firm's production opportunities in the short run. Therefore, it excludes the opportunity cost of using a bottleneck activity and may result in suboptimal production-related decisions.

The TOC and ABC, based on short-run variable or flexible costs, are both designed to evaluate the economics of short-run production-related decisions. However, advocates of the TOC and ABC, based on short-run cost, provide little or no guidance as to how decisions made with these models may be coordinated with longer-term decisions. Failure to coordinate short- and longer-term decisions may lead to a series of short-run decisions that become the firm's long-term strategic plan by default. The problem with this *ad hoc* approach to strategic planning is that a series of short-run decisions may be suboptimal relative to a decision made initially from a longer-term perspective. Conversely, long-term decisions frequently have near-term implementation issues. Failure to understand and act on these issues may delay and/or impair the implementation of longer-term decisions. Consequently, short- and long-run decisions must be integrated and coordinated to make resource allocation decisions that are optimal in the short, as well as the long term.

The purpose of this article is to discuss how an activity-based cost system may be used to measure the economic attributes of short-term resource allocation decisions. The author demonstrates that an activity-based model incorporating the short-run flexible cost of an activity's resources and its usage of a bottleneck activity can be used to measure the short-run cost of activities and the products they are used to produce. The information developed from the model may be used to evaluate the economic consequences of short-run product mix and other production-related decisions. Equally important, it may be integrated with information from a traditional ABC model to coordinate short- and longer-term resource allocations.

The remainder of the article is organized as follows. The next section discusses attributes of short- and long-run product mix decisions. The following section examines the TOC and ABC and their strengths and limitations. The section after that presents a numerical example to demonstrate how ABC may be used to make short-run product mix decisions and how short- and long-run decisions may be integrated. Last, the summary and conclusions are presented.

PRODUCT MIX DECISION

One of the most crucial production-related decisions of the firm involves selecting which products to produce, which to postpone, and which to delete from the firm's product line. The product mix decision is determined, in large part, by the economics of their production. However, the costs that are relevant for evaluating a product mix are influenced by the decision's time horizon. In the short run, the costs relevant for evaluating a product are the flexible cost of resources used in its production, as well as the opportunity cost of using a bottleneck activity. In the long run, a company's management can adjust its contractual and managerial policies governing labor and overhead resources to meet its production needs. In effect, over an extended time horizon, a company's committed cost is subject to management control. The ability to change these costs over the long run transforms them from a committed into a flexible cost. Therefore, the incremental cost for evaluating the economics of manufacturing a product in the long run is the cost of all resources used in its production.

While production-related decisions are heavily influenced by economic considerations, other attributes of the production process can also play a significant role in determining which products to produce. One of the most important of these factors is the capacity of the firm's production activities. A firm's production and support activities interact to create a system for developing and manufacturing a firm's products. In the short run, the capacity of the firm's support and production activities is fixed. Therefore, the most constrained activity is the system's bottleneck that restricts its operations and determines the production opportunities available to the firm. If the firm attempts to minimize inventory and there are not alternative uses for production-related activities, a bottleneck activity limits the use of resources by non-bottleneck activities, causing the firm to incur unused capacity. The cost of unused resources represents expenditures that increase the cost of the firm's operations and decrease its profitability. Consequently, the selection of a product mix and its profitability, in the short run, is heavily influenced by the capacity of the firm's support and production activities.

In the long run, a firm's management can adjust the capacity of its production and support activities. Therefore, the product mix decision can be made independent of capacity considerations. However, to achieve the profitability forecast from analysis of products, the capacity of the firm's support and production activities must be adjusted to the capacity needed to produce the products. If an activity has less capacity than required to manufacture a product mix, a bottleneck will be created that restricts production and changes the set of products that may be optimal to produce. Conversely, if some activities have more capacity than needed in the long run, then unused capacity cost will be incurred. The cost of unused capacity represents a non-value added cost that decreases the profit that may be earned from a product mix. Consequently, the profitability of the product mix selected in the long run implicitly assumes that the capacity of the firm's production and support activities will be adjusted to that needed to produce the product mix.

THE THEORY OF CONSTRAINTS AND ACTIVITY-BASED COST

The TOC and ABC were developed to provide information to evaluate the financial consequences of production-related decisions. However, the two systems make radically different assumptions about the economics of manufacturing a firm's products. Goldratt (1990a) developed the TOC to overcome the limitations of traditional cost accounting systems and thereby provided information for guiding production-related decisions. The objective of the TOC is to maximize the goal of an organization that is limited by a constraint (Goldratt, 1990b). Under the TOC, the firm's production system is managed with respect to the constraint or bottleneck, while resources are expended to relieve this limitation on the system (Goldratt, 1990b). When the constraint is removed and the firm moves to a higher level of goal attainment, a new bottleneck will appear and the cycle of managing the system with respect to the new constraint is repeated, leading to successive improvements in the firm's operations and performance.

The TOC is implemented through three measurements: (1) throughput, the rate at which the system generates money through sales, (2) inventory, all money the system invests in purchasing items the system intends to sell, and (3) operating expenses, all money the system spends turning inventory into throughput (Goldratt and Fox, 1986). Under this measurement system, direct material is treated as a variable cost. Conversely, labor and overhead are assumed to be resources the firm is committed to acquiring and unable to influence (Goldratt, 1990a). Therefore, the cost of labor and overhead supplied to production is treated as a period expense. Operationally, the TOC involves maximizing throughput subject to the firm's bottleneck activities. As noted by Goldratt (1990a), the use of the TOC represents a paradigm shift from using cost accounting to using the TOC's measurement system to guide production-related decisions.

Unlike the TOC, ABC assumes that labor and overhead costs are relevant to resource allocation decisions. Under ABC, an activity's resources are disaggregated into either flexible or committed cost (Cooper and Kaplan, 1992). Flexible cost represents the cost of resources acquired as demanded, while committed cost represents the cost of resources contracted for in advance of usage. Under ABC, an activity's flexible and committed or total costs are divided by its practical capacity to develop a cost driver rate that measures the cost of an activity's service. Under this procedure, an activity's committed cost is transformed into a flexible cost to reflect the cost of an activity's services. Using the quantity of an activity's service or activity cost driver consumed in a product's production, ABC traces the cost of an activity's resources to the products it is used to produce. As noted by Kaplan and Cooper (1998), ABC reflects a long-term perspective of cost behavior. Conversely, the TOC represents a near-term model of a firm's cost.

Studies of the TOC and ABC

Studies comparing the TOC and ABC have examined the competing and complementary aspects of the two paradigms. Goldratt (1990a) argues extensively that labor and overhead costs are committed costs and are irrelevant for resource allocation decisions. Consequently, efforts to trace labor and overhead to products with cost systems, such as ABC, serve no useful purpose. Low (1992) and Spoede *et al.* (1994), using numerical examples, illustrate that the TOC leads to a more profitable product mix than ABC. Low noted that the "activity-based cost allocation procedure was a great deal more complex than traditional costing procedures, but it was not particularly helpful in a strategic sense" (1992: 36). Conversely, Kee (1995), using a similar example, illustrates that an ABC model integrating the cost and capacity of production activities outperforms the TOC. The profitability of the product mixes selected with the TOC and ABC in the Low (1992) and Spoede *et al.* (1994) studies was based on the resources supplied to production, while the profitability of the product mix in the Kee (1995) study was based on the resources used in production. In effect, labor and overhead were treated as committed costs in the Low (1992) and Spoede *et al.* (1994) studies and treated as flexible costs in the Kee (1995) study. Consequently, the superiority of the TOC and ABC, relative to each other in the Low (1992), Spoede *et al.* (1994), and Kee (1995) studies, is dependent upon the assumptions made about labor and overhead resources.

The complementary nature of the TOC and ABC has been examined by Bakke and Hellberg (1991), MacArthur (1993), and Huang (1999). They suggest that the TOC should be used in the short run, while ABC should be used for the longer term. However, as noted by Bakke and Hellberg (1991), there is no clear demarcation between short-term and long-term decisions, and short-term decisions may have longer-term economic consequences. Therefore, efforts to determine precisely when the firm should use the TOC and when it should use ABC may be problematic. Furthermore, integrating short- and long-run decisions with the TOC and ABC may be difficult due to the different assumptions and methodologies of the two models. For example, short-run decisions made with the TOC may adversely affect implementing longer-term decisions made with ABC.

Proposed Modification of ABC

To overcome the limitations of ABC for evaluating the economic implications of operational decisions, this article modifies ABC to reflect the short-run flexible cost of an activity's resources and its usage of a bottleneck activity's capacity. The costs of an activity's resources are disaggregated into their short-run flexible and committed components, as suggested by Kaplan and Atkinson (1998). In the short run, an activity's committed cost is a sunk cost that is irrelevant for decision making. Therefore, cost driver rates are computed based on an activity's flexible cost. When the flexible cost driver rates of the firm's support and production activities are traced to the products they are used to produce, it measures their short-run, or incremental, cost of production. To incorporate the effect of a bottleneck activity, a product's profitability is measured based on its usage of the firm's most constrained activity. These modifications enable ABC to reflect the short-run flexible and opportunity costs relevant for making near-term resource allocation decisions.

The ABC model, based on short-run flexible cost and bottleneck utilization, is referred to as an operational ABC model, throughout the remainder of the article, to reflect its short-term perspective and to distinguish it from the traditional ABC model. The operational ABC model incorporates many of the features of earlier proposals for making short-run decisions. The proposed model reduces to the TOC when all labor and overhead are committed costs in the short run. Therefore, it is consistent with the suggestion of Bakke and Hellberg (1991), MacArthur (1993), and Huang (1999) for using the TOC for making short-run, production-related decisions. The short-run flexible and committed costs of the operational ABC model are consistent with Woods' (1992) and Christensen and Sharp's (1993) suggestion that the short-run cost of resources should be disaggregated into their variable and fixed components. However, unlike earlier suggestions, with the exception of the TOC, the operational ABC model incorporates bottleneck utilization that is frequently critical for making short-run resource allocation decisions. Also, as illustrated in the article, the operational ABC model provides information that may be combined with a traditional ABC model to coordinate short- and long-run, production-related decisions.

EVALUATING SHORT- AND LONG-TERM PRODUCTION DECISIONS

A Numerical Example

To illustrate how the short- and long-term economic implications of product mix decisions may be evaluated with ABC, consider the example provided in Table 1. XYZ, Inc. is a medium-sized firm with three support activities—set-up, purchasing, and engineering—and one production activity—assembly. To facilitate discussion, the number of support and production activities has been limited. However, the principles and concepts discussed in the article are applicable to firms with a larger number of support and production activities. In producing XYZ Inc.'s products, direct material, labor, and assembly overhead costs are incurred at the unit-level, set-up and purchasing costs are incurred at the batch level, and engineering cost is incurred at the product level. In Panels I, II, and III of Table 1, a cost driver rate for assembly, purchasing and set-up, and engineering, respectively, is computed and then traced to the products produced by the firm in Panel IV.

In Panel I, a total cost driver rate for the assembly activity was computed by dividing its expected total cost of $4,800,000 by its practical capacity of 200,000 machine hours. The total cost driver rate for assembly is $24 per machine hour. In the last two columns of Panel I, the assembly overhead is disaggregated into its short-run flexible and committed components. The time frame used for classifying the cost of resources as flexible or committed in the short run was one year. The flexible and committed assembly overhead was divided by the assembly activity's practical capacity to derive a flexible and committed cost driver rate of $8 and $16 per machine hour, respectively.

The total cost driver rate represents the cost of the assembly activity measured by a traditional ABC model, while the flexible cost driver rate represents the cost measured by an operational ABC model. Conceptually, the total cost driver rate meas-

TABLE 1
XYZ, Inc.
Revenue, Cost, and Operating Structure

Panel I: Unit-Level Activities

	Product X1	X2	X3	Total Cost	Flexible Cost	Committed Cost
Assembly-Machine Hours	0.5	1	2			
Assembly Overhead						
Expected Cost				$4,800,000	$1,600,000	$3,200,000
Practical Capacity In MH				200,000	200,000	200,000
Overhead Per MH				$24	$8	$16

Panel II: Batch-Level Activities

	X1	X2	X3	Total Cost	Flexible Cost	Committed Cost
Set-up						
Batch Size	1000	400	200			
Hours/Batch	1	2	5			
Expected Cost				$2,150,000	$215,000	$1,935,000
Practical Capacity				4,300	4,300	4,300
Cost Per Set-up Hour				$500	$50	$450
Purchasing						
Batch Size	1000	500	500			
Orders/Batch	2	10	30			
Expected Cost				$1,180,000	$472,000	$708,000
Practical Capacity				11,800	11,800	11,800
Cost Per Purchase Order				$100	$40	$60

Panel III: Product-Level Activities

	X1	X2	X3	Total Cost	Flexible Cost	Committed Cost
Engineering						
Drawings/Product	100	200	700			
Expected Cost				$1,200,000	$180,000	$1,020,000
Practical Capacity				1,000	1,000	1,000
Cost Per Drawing				$1,200	$180	$1,020

Panel IV: Activity-Based Cost

	Product X1 Total Cost	Product X1 Flexible Cost	Product X2 Total Cost	Product X2 Flexible Cost	Product X3 Total Cost	Product X3 Flexible Cost
Unit Cost						
Direct Material Cost	$20.00	$20.00	$20.00	$20.00	$30.00	$30.00
Labor Cost ($32/DLH)*	$8.00	$0.00	$8.00	$0.00	$4.00	$0.00
Assembly Overhead	$12.00	$4.00	$24.00	$8.00	$48.00	$16.00
Batch-Level Cost						
Set-up	$0.50	$0.05	$2.50	$0.25	$12.50	$1.25
Purchasing	$0.20	$0.08	$2.00	$0.80	$6.00	$2.40
Product-Level Cost						
Engineering	$0.30	$0.05	$1.14	$0.17	$7.64	$1.15
ABC Cost	$41.00	$24.18	$57.64	$29.22	$108.14	$50.80
Price	$61.00	$61.00	$100.00	$100.00	$190.00	$190.00
Profit	$20.00	$36.82	$42.36	$70.78	$81.86	$139.20
Expected Demand	400,000	400,000	210,000	210,000	110,000	110,000

*Direct labor hours (DLH) is a committed cost with a capacity of 168,000 hours.

ures the cost of all resources used to produce an hour of machine hour service, while the flexible cost driver rate reflects the incremental cost of producing an hour of machine service in the short run. The difference between the two rates is the committed cost driver rate for assembly. The committed cost for the assembly activity will be incurred in the short run, whether machine hours are used in production or not. Therefore, committed cost is not relevant for short-run decisions. However, they are relevant in the long run and are included in the cost driver rate of the traditional ABC model. A unit of Product X1, X2, and X3 consumes .5, 1, and 2 machine hours, respectively, in its production. Using the assembly cost driver rates computed in Panel I, the total assembly cost traced to Products X1, X2, and X3 in Panel IV is $12, $24, and $48, while the short-run flexible cost of assembly traced to each product is $4, $8, and $16, respectively.

The cost driver rates for XYZ, Inc.'s batch-level activities are given in Panel II. For the first batch-level activity, set-up, the total cost driver rate of $500 per set-up hour was computed by dividing its total expected cost of $2,150,000 by its practical capacity of 4,300 set-up hours. In the last two columns of Panel II, the set-up activity's total costs are disaggregated into its short-run flexible and committed components. The flexible and committed costs were divided by the set-up activity's practical capacity to determine a flexible and committed cost driver rate of $50 and $450 per set-up hour, respectively. The total and flexible cost driver rates were multiplied by the set-up hours required to produce a batch of each product and divided by the number of units in the batch to determine each product's set-up cost per unit in Panel IV. For example, Product X1 requires one hour of set-up time to produce a batch of 1,000 units. Therefore, Product X1's total and flexible set-up costs are $0.50 and $0.05 per unit, respectively (($500 per set-up hour * 1 hour) ÷ 1,000 units) and (($50 per set-up hour * 1 hour) ÷ 1,000 units). Total and flexible cost driver rates for the purchasing activity and their conversion to a unit product cost were computed in a similar manner.

In Panel III, cost driver rates for XYZ, Inc.'s product-level activity, engineering, are given. Engineering's expected total, flexible, and committed costs were divided by the activity's practical capacity of 1,000 drawings to derive total, flexible, and committed cost driver rates of $1,200, $180, and $1,020 per drawing, respectively. The total and flexible cost driver rates were multiplied by the number of drawings required to design a product and divided by the product's expected demand (see Panel IV). For example, Product X1 requires 100 engineering drawings. Therefore, the total and flexible engineering costs used to design Product X1 are $120,000 and $18,000, respectively. These costs were divided by Product X1's expected demand of 400,000 units to derive its total and flexible engineering costs per unit in Panel IV of $0.30 and $0.05, respectively.

In the last panel of Table 1, Panel IV, the unit cost, price, profit, and expected demand for each of XYZ, Inc.'s three products are given. The cost of direct material and labor was traced directly to each product, while the cost of assembly, set-up, purchasing, and engineering was traced through the cost driver rates computed in Panels I, II, and III. In Panel IV, total and flexible costs are computed for each of XYZ, Inc.'s three products. The total cost for each product represents its traditional activity-based cost. For example, the total cost of Product X1, $41.00, represents the cost of the flexible and committed resources used in its production. Conversely, the flexible cost for each product in Panel IV reflects the change in cost that will occur from producing the product in the short run. For example, the flexible cost of Product X1, $24.18, measures the incremental cost of manufacturing the product in the near term. A product's total and flexible costs measure the two extremes in a product's cost with respect to time. More importantly, they represent two measures of the economics of manufacturing a product that must be incorporated into production-related decisions. Each product's total and flexible costs were subtracted from its current sales price to measure its long- and short-term profitability. If a product's current and long-term prices are expected to differ, then its long-term price should be used to evaluate long-term, production-related decisions. In Panel IV, the profit of Product X1, based on its long-run and near-term cost, is $20.00 and $36.82, respectively.

Short-Run Product Mix Decisions

Product mix decisions, in the short run, are jointly determined by the economics of their production and the firm's production capacity. In the near term, the firm's production capacity is fixed, and the most constrained activity, or bottleneck, determines what can be produced, as well as a product's relative profitability. To identify the products that are the most profitable to manufacture in the short term, XYZ's bottleneck activity is identified in Panel I of Table 2. Panel I compares each activity's available capacity, measured in units of its cost driver, with the demand for its capacity over a one-year time horizon. That is, the time horizon for evaluating short-run decisions is one year. The demand for an activity's capacity was computed by multiplying a product's expected demand times the quantity of its unit-, batch-, or product-level services required to manufacture the product's expected demand in Table 1. The capacity required for each product was added to get "Total Demand." The capacity in "Total Demand" was subtracted from "Available Capacity" to get each activity's unused resources, or "Excess Capacity." As indicated, each activity, except assembly, has sufficient capacity to produce the firm's products. Therefore, the assembly activity is the most constrained of the firm's activities, or its bottleneck activity. If two or more activities, in Panel I of Table 2, had negative excess capacity, then the firm is faced with the potential for interactive constraints. That is, the selection of an optimal product mix can be affected by two or more constraints simultaneously. Under these conditions, mathematical programming will be required to solve for the optimal product mix. See Kee (1995), Malik and Sullivan (1995), and Kee (2000) for a discussion and examples of selecting an optimal product mix using mixed integer programming.

In Panel II of Table 2, an optimal product mix was selected for the operational ABC model. To incorporate bottleneck usage, the unit profit of each product, based on its flexible cost in Panel IV of Table 1, was divided by the number of machine hours used from the assembly, or bottleneck, activity. As indicated, Product X1 has the highest profit per machine hour, followed by Products X2 and X3, respectively. The optimal product mix was determined by producing as many units of the highest-ranked product, then producing the

TABLE 2
XYZ, Inc.
Bottleneck Identification and Product Mix Selection

Panel I: Bottleneck Identification		Direct Labor	Assembly	Set-up	Purchasing	Engineering
Available Capacity		168,000	200,000	4,300	11,800	1,000
	Expected	(DLH)	(MH)	(Hours)	(Orders)	(Drawings)
Resource Demand	Demand					
Product X1	400,000	100,000	200,000	400	800	100
Product X2	210,000	52,500	210,000	1,050	4,200	200
Product X3	110,000	13,750	220,000	2,750	6,600	700
Total Demand		166,250	630,000	4,200	11,600	1,000
Excess Capacity		1,750	-430,000	100	200	0
Bottleneck		No	Yes	No	No	No

	Product X1	X2	X3
Panel II: Operational ABC Model			
Profitability Per Unit	$36.82	$70.78	$139.20
Assembly MH Per Unit	0.5	1.0	2.0
Profit Per MH	$73.64	$70.78	$69.60
Profitability Ranking	1	2	3
Optimal Product Mix*	400,000	0	0
Panel III: ABC with Capacity Model			
Profitability Per Unit	$20.00	$42.36	$81.86
Assembly MH Per Unit	0.5	1.0	2.0
Profit Per MH	$40.00	$42.36	$40.93
Profitability Ranking	3	1	2
Optimal Product Mix*	0	200,000	0
Panel IV: Traditional ABC Model			
Profitability Per Unit	$20.00	$42.36	$81.86
Price	$61.00	$100.00	$190.00
Profit to Price Ratio	33%	42%	43%
Profitability Ranking	3	2	1
Optimal Product Mix*	0	0	100,000

*Number of units that can be produced with the capacity of the assembly activity.

second-ranked product, and so forth, until the capacity of the bottleneck activity was consumed. The optimal product mix selected using these procedures consisted of producing 400,000 units of Product X1 and zero units of Products X2 and X3. This is the same product mix that would have been chosen if the TOC had been used to select an optimal product mix.

To evaluate the relative profitability of the product mix selected with the operational ABC model, a product mix was selected with two other ABC models: an ABC model, based on total cost and bottleneck utilization, and a traditional ABC model. In Panel III, an optimal product mix was selected for ABC, based on total cost and bottleneck utilization. This is the ABC model used in the Kee (1995) study and will be referred to as an ABC with capacity model. The unit profit for each product, based on its total cost, was divided by the number of machine hours used from the assembly activity. As indicated in Panel III, Product X2 has the highest profitability per machine hour, followed by Products X3 and X1, respectively. An optimal product mix was selected for the ABC with capacity model using the procedures outlined for selecting an optimal product mix in Panel II. The optimal product mix for the ABC model in Panel III would consist of producing 200,000 units of Product X2 and zero units of the other products. Although the expected demand for Product X2 is 210,000 units, the capacity of the assembly activity is sufficient to produce only 200,000 units.

In the last panel, Panel IV, an optimal product mix for an ABC model, based on total cost and no bottleneck utilization, is given. The cost system used in Panel IV is a traditional ABC model. The products in Panel IV were ranked in terms of their relative profitability by dividing each product's profit by its price. Based on profit margin, Product X3 would be ranked most profitable, followed by Products X2 and X1, respectively. While the bottleneck activity was ignored in ranking each product's profitability, a bottleneck would restrict its production in the short run. Therefore, as many units of Product X3 were produced as the capacity of the bottleneck permitted, then Product X2, etc. The optimal product mix for the traditional ABC model consisted of 100,000 units of Product X3 and zero units of the other products.

Table 3 provides an annual income statement for the product mix selected with each ABC model in Table 2. The product mix selected with each model is listed below the model's net income. In Table 3, revenue for each ABC model was computed by multiplying its product mix by the product prices listed in Panel IV of Table 1. Direct material, labor, and assembly overhead costs were computed by multiplying the quantity of each product in the optimal product mix by the product's total direct material, labor, and assembly overhead costs per unit in Panel IV of Table 1. Conversely, set-up and purchasing costs were computed by determining the number of batches required to produce each model's product mix and multiplying by their respective total batch-level costs. For example, Product X1 is produced in batches of 1,000 units due to the need to clean and recalibrate the assembly machines. Therefore, the set-up cost to produce the 400,000 units of Product X1 for the operational ABC model was $200,000 ((400,000 units ÷ 1,000 units/batch) * $500/batch). Engineering cost was computed by multiplying the number of engineering drawings required to design each product times the total cost per engineering drawing. The total cost of the resources used to produce each model's product mix was subtracted from its revenue to measure income based on the resources used in production.

In the short run, the firm's nonbottleneck activities may have unused capacity, causing the firm to incur additional cost. The cost of unused resources for each activity is its unused capacity times its committed cost driver rate. Flexible resources are acquired as needed for production. Therefore, the flexible cost of unused resources can be avoided. For example, XYZ, Inc. has direct labor capac-

TABLE 3
XYZ, Inc.
Short-Run Production Mix Income

	Operational ABC Model	ABC with Capacity Model	Traditional ABC Model
	Product X1	Product X2	Product X3
Revenue	$24,400,000	$20,000,000	$19,000,000
Resources Used:			
Direct Material	$8,000,000	$4,000,000	$3,000,000
Direct Labor	$3,200,000	$1,600,000	$400,000
Assembly Overhead	$4,800,000	$4,800,000	$4,800,000
Set-up	$200,000	$500,000	$1,250,000
Purchasing	$80,000	$400,000	$600,000
Engineering	$120,000	$240,000	$840,000
Total Cost	$16,400,000	$11,540,000	$10,890,000
Income Based On Resources Used	$8,000,000	$8,460,000	$8,110,000
Unused Resources:			
Direct Labor	$2,176,000	$3,776,000	$4,976,000
Assembly Overhead	$0	$0	$0
Set-up	$1,755,000	$1,485,000	$810,000
Purchasing	$660,000	$468,000	$348,000
Engineering	$918,000	$816,000	$306,000
Total Cost	$5,509,000	$6,545,000	$6,440,000
Net Income	$2,491,000	$1,915,000	$1,670,000
Product Mix			
Product X1	400,000	0	0
Product X2	0	200,000	0
Product X3	0	0	100,000

ity of 168,000 hours. In Panel IV of Table 1, it takes one-fourth direct labor to produce a unit of Product X1 and X2 and one-eighth direct labor hour to produce a unit of Product X3. However, only 100,000 labor hours are needed to produce the product mix for the operational ABC model, leaving unused labor capacity of 68,000 hours. Since direct labor is a committed cost in the short run, the cost of unused labor capacity is $2,176,000, or 68,000 unused hours * $32/hour. The set-up activity has a capacity of 4,300 hours. However, only 400 set-up hours are required to produce the product mix for the operational ABC model, leaving unused capacity of 3,900 set-up hours. The cost of unused set-up capacity is $1,755,000, or 3,900 unused set-up hours times the committed cost driver rate of $450 per set-up hour (see Panel II of Table 1). The costs of the other activities' unused resources and those of the other ABC models were computed in a similar manner. The cost of unused resources was subtracted from income, based on resources used in production, to determine each ABC model's net income.

An analysis of Table 3 indicates the product mix selected with operational ABC has a higher annual net income than the product mixes selected with each of the other ABC models. The net income of the operational ABC model relative to that of a traditional ABC model in Table 3 illustrates the assertion of Theeuwes and Adriaansen's (1994) that a traditional ABC model is unsuitable for operational decisions. The traditional ABC model overstates the costs that are relevant for making a product mix decision and ignores the opportunity cost of using constrained resources in making short-run product mix decisions. However, the assertion that ABC is unsuitable for short-run decisions is a result of how ABC has been implemented, rather than an inherent limitation of the model. When ABC incorporates the flexible costs of resources and bottleneck utilization, it reflects the economic and physical attributes of short-run, production-related decisions. As illustrated in Table 3, ABC, based on flexible cost and bottleneck utilization, is suitable for operational product mix decisions.

The operational ABC model is applicable to a wide range of production-related decisions. A product's activity-based cost, based on its flexible cost and bottleneck utilization, measures the incremental and opportunity costs of producing a product needed for short-run pricing, special order, and outsourcing decisions. A product's opportunity cost is the profit given up from using a unit of the bottleneck to manufacture the product relative to the profit that could be earned from producing the firm's most profitable product. For example, the opportunity cost of producing a unit of Product X2 is $2.86, the $70.78 of profit earned from using an hour of the assembly activity to produce one unit of X2 less the profit of $73.64 that could be earned from using an hour in assembly to produce two units of Product X1.

The operational ABC model also provides information for making current process improvement decisions. In the short run, protecting the bottleneck activity is crucial for realizing the potential profit of the optimal short-run product mix. For example, every hour of the assembly activity lost through downtime, inefficiency, or other causes results in two less units of Product X1 being produced. The incremental cost of direct material, assembly overhead, set-up, and purchasing per unit of Product X1 is $24.13 ($24.18 - $.05) per unit, for a near-term contribution margin of $36.87 per unit. Engineering cost is incurred before the first unit of a product is produced. Therefore, the flexible engineering cost would be incremental with respect to the decision to produce a product, but not an incremental cost with respect to the volume in which it is produced. Therefore, every hour of the bottleneck not used productively results in a lost contribution margin of $73.74, the lost contribution margin from the units of Product X1 that could be produced from an hour in the assembly activity.

Long-Run Product Mix Decisions

The higher income of the product mix selected with the operational ABC model is a result of the short-run time horizon selected for making production-related decisions in Table 3. However, over an extended time period, a firm can modify its contractual obligations and management polices to transform its committed resources into flexible costs. This enables the firm to adjust the resources supplied to equal the demand for these resources. In effect, the firm can eliminate the cost of unused resources. Under these conditions, a firm's long-term income is a function of the cost of the resources used in production. As indicated in Table 3, when income is measured, based on the resources used in production, the ABC with capacity and the traditional ABC models lead to a higher income than the operational ABC model. As noted earlier, the TOC would have selected the same product mix as the operational ABC model. Therefore, the ABC with capacity and the traditional ABC models lead to a more profitable product mix than the TOC. The operational ABC model, like the TOC, understates the cost of manufacturing products over the longer term and may lead to suboptimal resource allocations. Consequently, the usefulness of the operational ABC model, like the TOC, is restricted to short-run, production-related decisions.

When the capacity of one or more of the firm's support and production activities is limited in the long term, it creates a bottleneck that restricts the production opportunities available to the firm. Equally important, it creates an opportunity cost that affects the economics of products that use the bottleneck activity's services. The traditional ABC model ignores the implications of activities with limited capacity. Conversely, the ABC with capacity model incorporates the opportunity cost of a support or production activity with limited capacity by computing a product's profit based on its use of bottleneck activities' service. As indicated in Table 3, the ABC with capacity model leads to the selection of a product mix with a higher income, based on resources used in production, than the traditional ABC model. Therefore, when one or more of a firm's support and production activities has limited capacity in the long term, the ABC with capacity model, rather than the traditional ABC model, should be used to evaluate the economics of production-related decisions.

The traditional ABC model is used to evaluate the economics of products independent of the capacity of the firm's support and production activities. Consequently, after a product mix has been selected with the traditional ABC model, the capacity of the firm's support and production activities must be adjusted to that needed to produce the product mix. This requires adding resources to activities without sufficient capacity to prevent production bottleneck(s) that would restrict manufacturing of the product mix and/or change the economics of its production. Conversely, the resources of activities with excess capacity must be reduced to that needed to manufacture the product mix to prevent unused capacity cost. Failure to adjust the firm's production structure to that needed to manufacture the product mix selected with a traditional ABC model may result in the product mix being unfeasible and/or suboptimal for the firm to produce.

To illustrate the selection of a product mix with a traditional ABC model, consider the data in Panel IV in Table 2. As indicated, Product X3 is the most profitable product for the firm to manufacture. However, as indicated in Panel III of Table 2, given the firm's current production capacity, product X2 is more profitable to produce. Therefore, to produce the product mix identified with the traditional ABC model, the capacity of the firm's support and production activities must be adjusted to that needed to produce Product X3. To determine the changes in XYZ, Inc.'s

TABLE 4
XYZ, Inc.
Long-Run Product Mix Income

Panel I: Resource Supply and Demand

		Direct Labor	Assembly	Set-up	Purchasing	Engineering
Available Capacity		168,000	200,000	4,300	11,800	1,000
	Expected	(DLH)	(MH)	(Hours)	(Orders)	(Drawings)
Resource Demand	Demand					
Product X3	110,000	13,750	220,000	2,750	6,600	700
Excess Capacity		154,250	-20,000	1,550	5,200	300

Panel II: Projected Income

	Product X1	Product X2	Product X3
Revenue	$24,400,000	$21,000,000	$20,900,000
Resources Used			
Direct Material	$8,000,000	$4,200,000	$3,300,000
Direct Labor	$3,200,000	$1,680,000	$440,000
Assembly Overhead	$4,800,000	$5,040,000	$5,280,000
Set-up	$200,000	$525,000	$1,375,000
Purchasing	$80,000	$420,000	$660,000
Engineering	$120,000	$240,000	$840,000
Total Cost	$16,400,000	$12,105,000	$11,895,000
Income Based On Resources Used	$8,000,000	$8,895,000	$9,005,000
Demand in Units	400,000	210,000	110,000

production structure required to manufacture Product X3, the resources currently available and the demand for these resources are given in Panel I of Table 4. The resources currently available are listed in the row labeled "Available Capacity" and those needed to produce the expected demand for Product X3 are listed in the row labeled "Product X3." The difference between the resources currently available and those needed to produce Product X3 is listed in the row labeled "Excess Capacity." As indicated, all of the activities have excess capacity, except the assembly activity. To produce the expected demand for Product X3, XYZ, Inc.'s management must add 20,000 machine hours of capacity to the assembly activity. The cost of the resources added to expand the capacity in assembly was assumed to be proportional to its current activity cost driver rate of $24 per machine hour. Conversely, the resources of activities with excess capacity were reduced to the level needed to produce the expected demand for Product X3 to prevent incurring the cost of unused resources.

To evaluate the long-term economic implications of manufacturing Product X3, relative to the firm's other products, an annual income statement for Products X1, X2, and X3 is given in Panel II of Table 4. Like Product X3, the resources of XYZ, Inc.'s support and production activities were adjusted to that needed to manufacture only Products X1 and X2. This involved adding 0 and

10,000 machine hours in the assembly activity to produce the expected demand for Products X1 and X2, respectively. Like Product X3, the cost of the resources added to expand the capacity in assembly to produce Product X2 was assumed to be proportional to its current activity cost driver rate of $24 per machine hour. Also, like Product X3, resources in excess of those needed to produce Products X1 and X2 were removed from the firm's production structure to prevent unused capacity cost. In instances where productive resources are acquired in large, discreet amounts, some unused capacity may be inevitable when adjusting the supply and demand for the firm's resources.

The revenue and cost of resources used to manufacture each product in Panel II of Table 4 were computed similarly to the procedures used to compute these items in Table 3. An analysis of Table 4 indicates that when the bottleneck activity is removed the product mix selected with the traditional ABC model, Product X3, leads to a higher income than that of the product mixes selected with the other ABC models. In Table 4, the expected demand and revenue for Product X1 exceeded that for Product X2, which, in turn, exceeded that for Product X3. Therefore, Product X3 was at a disadvantage with respect to Products X1 and X2 in terms of expected demand and revenue. If the demand for Products X1 and X2 was significantly greater than their current amounts, then the product mix with the highest income would be a function of each product's relative demand and profitability. While the revenue for Products X1 and X2 is greater than that of Product X3, the revenue of the three products is sufficiently comparable so that they can be evaluated based on measures of their relative profitability. As indicated in Panel IV of Table 1 and Panel IV in Table 2, Product X3's profitability per unit and as a percent of its sales price, respectively, is higher than that of the other products. Table 4 verifies that, when products are evaluated based on the economics of their production and the firm's resources are adjusted to manufacture the product mix, a traditional ABC model selects the product mix that maximizes the firm's income.

A traditional ABC model reflects the cost of all resources necessary to produce a product. Consequently, a product's price relative to its activity-based cost measures the value added or value lost from its production. This information is relevant for long-term product mix, pricing, outsourcing, and other production-related decisions. A traditional ABC model also provides information needed to stimulate long-term process improvement. This may take the form of reducing the quantity of resources needed by products that consume the services of a bottleneck activity. This enables the firm to eliminate a bottleneck through improving its efficiency, rather than adding additional resources to the activity. Process improvement may also be directed at reducing the cost of support and production activities and the products they are used to manufacture. This may be accomplished by reducing the resources required to perform an activity's service and/or reducing the services from the firm's support and production activities required to manufacture a product. These efforts can significantly impact a product's cost, profitability, and the capacity of the support and production activities needed for its production.

Integrating Short- and Long-Run Product Mix Decisions

To illustrate how the short- and long-run economics of the firm's operations may be integrated, consider the data in Table 2. As indicated in Panels II and IV, Product X1 is the most profitable product to produce in the short run, but the least profitable to manufacture in the long term. Conversely, Product X3 is the least profitable to produce currently, but the most profitable to manufacture over the long term. The profitability rankings in Panels II and IV of Table 2 reflect the frequent conflict between decisions that are optimal in the short run versus those that are optimal in the longer term. To integrate short- and long-run decisions, managers must understand why this conflict arises and the set of actions necessary for its resolution. The higher profitability of Product X1 in the short run is a function of the firm's current production structure. The limited capacity of the assembly activity creates an opportunity cost for products that use its services. As indicated in Panel II of Table 2, Product X1 is more profitable to manufacture in the short run due to its lower usage of the bottleneck activity's services and lower opportunity cost relative to that of the other products. Conversely, when products are evaluated independent of the limitations of the firm's current production structure, Product X3 has the highest value added, relative to the firm's other products. Therefore, the conflict between producing Product X1 in the near term and the need to produce Product X3 in the long term is a function of the firm's current production structure.

Integrating XYZ, Inc.'s short- and long-run product mix decisions involves determining the period for producing Product X1 and the point at which it should begin to manufacture Product X3. To produce Product X3, the firm must expand the capacity of the assembly activity by 20,000 machine hours or reduce the time required in assembly to manufacture Product X3 by an equivalent amount. This period of time determines how long Product X1 should be produced. During this period, the firm's marketing department should develop strategies to support the transition from selling Product X1 to Product X3. This may require outsourcing Product X1 to maintain the firm's current customers, as well as advertising and promotion campaigns to attract customers to Product X3 when its production begins. While Product X1 is being produced, resources in excess of those needed to produce either Product X1 or Product X3, whichever level of excess capacity is the lowest, should be removed from the firm's production structure. For example, the direct labor hours required to produce Products X1 and X3 are 100,000 and 13,750, respectively. The firm currently has 168,000 labor hours of capacity available. The excess capacity for manufacturing Products X1 and X3 is 68,000 and 154,250 labor hours, respectively. Therefore, 68,000 labor hours should either be transferred to other uses within the firm or eliminated through not replacing workers who leave the firm or retire. The excess resources in the firm's other support and production activities should be analyzed and eliminated in a similar manner.

When the firm has eliminated the bottleneck in the assembly activity, production of Product X3 can begin. The resources that remain in excess of those needed for Product X3 production should then be eliminated. For example, assume that XYZ, Inc.'s management has reduced its labor hours to 100,000 when Product X3 begins production. Since only 13,750 labor hours are needed to manufacture Product X3, an additional 86,250 labor hours should be used elsewhere in the firm's operations or else eliminated through worker attrition. Similarly, any excess resources remaining in the firm's other support and production activities must be eliminated. As the firm is able to adjust assembly capacity, it can move from its optimal short- to its optimal long-run product mix. Equally important, as the firm is able to adjust the capacity of its non-bottleneck activities from that needed to produce its optimal short-run product mix to that needed to manufacture its optimal long-term product mix, the firm will be able to move from its maximum short-run to its maximum long-term income.

SUMMARY AND CONCLUSIONS

ABC has been criticized for its inability to support short-term, production-related decisions (Theeuwes and Adriaansen, 1994). In this article, an activity-based model was modified to reflect the flexible cost of resources and usage of a bottleneck activity's resources. This enables ABC to reflect the incremental and opportunity costs of producing a product in the short run. As illustrated in the article, the operational ABC model will identify an optimal short-run product mix when the traditional ABC model may not. Equally important, an operational ABC model provides information relevant for short-run pricing, outsourcing, process improvement, and other production-related decisions.

The TOC has been proposed for evaluating the economic consequences of operational production-related decisions (Bakke and Hellberg, 1991; MacArthur, 1993; Huang, 1999). The operational ABC model has several advantages over the TOC. First, the operational ABC model reduces to the TOC when all labor and overhead resources are committed costs. However, in cases where some labor and overhead resources are a flexible cost in the short run, the operational ABC model reflects these resources as an incremental cost, while the TOC does not. This enables the operational ABC model to more accurately measure the incremental cost of production in the short run. Secondly, the operational ABC model is consistent with the underlying methodology of the traditional ABC model. This allows the two models to be used together to measure the short- and long-run economics of the firm's products from a common frame of reference.

The operational ABC model provides information needed for short-run, production-related decisions, while the traditional ABC model provides information needed for longer-term decisions. However, optimal short- and long-run production decisions may conflict. Therefore, information from the operational ABC model and a traditional ABC model may be integrated to coordinate short- and long-term decisions. Analysis of why short- and long-term decisions conflict is crucial for developing strategies that eliminate these problems. As these strategies are implemented, it enables the firm to move from its optimal near-term to its optimal long-term production decisions. Equally important, it enables the firm to restructure the resources of its support and production activities, to realize the profitability of long-term, production-related decisions revealed with a traditional ABC system.

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