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ACTIVITY-BASED COST-VOLUME-PROFIT ANALYSIS: ANOTHER APPROACH TO BREAK-EVEN ANALYSIS

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ABSTRACT
In order to be able to compete in highly competitive environments, managers must make correct decisions. Management accountants are among the managers whose decisions are exceedingly important for the success of their companies. Therefore, management accountants have to base their decisions on such systems that provide the best possible information. Otherwise, they cannot make sound and correct decisions. Nevertheless, the use of traditional product costing and cost management systems may lead management accountants to make wrong decisions. For example, Cost-Volume-Profit (CVP) analysis is one of the areas in which the use of traditional approaches can be misleading for managerial purposes. The aim of this paper is to identify how traditional CVP analysis leads managers to make wrong decisions. In addition, this paper also aims to show that the use of Activity-Based CVP analysis will give better results than those of the Traditional CVP analysis.

Keywords: Activity-based Costing; CVP analysis; Break-even Analysis;

ÖZET
Yüksek rekabete dayalı ortamlarda başarılı olabilmek için yöneticiler doğru kararlar vermek zorundadırlar. Yönetim muhasebecileri de, kararları işletmeler açısından çok önemli olan yöneticiler arasındadırlar. Bu nedenle yönetim muhasebecileri kararlarını verirken, işletmeye mümkün olan en iyi bilgiyi sağlayacak yöntemleri kullanmalıdırlar. Aksi halde işe yarar ve doğru kararlar vermeleri mümkün olmayabilir. Neyazık ki geleneksel maliyet ve yönetim sistemleri, yöneticilerin yanlış karar vermelerine neden olmaktadır. Örneğin, maliyet-hacim-kar analizi teknikleri, geleneksel yöntemlerin yönetim amaçları doğrultusunda yanlış karar verilmesine neden olan alanlardan birisidir. Bu çalışmanın amacı geleneksel maliyet-hacim-kar analizinin hatalara nasıl neden olabileceğini göstermektir. Ayrıca faaliyete dayalı maliyet sisteminin bu amaçla kullanılarak nasıl daha iyi sonuçlara ulaşılabileceği de açıklanacaktır.

Anahtar kelimeler: Faaliyete Dayalı Maliyet; Maliyet-Hacim Kar analizi; Başabaş noktası analizi.

Introduction

Traditional cost-volume-profit (CVP) analysis focuses on the number of units sold as the sole cost and revenue driver. In other words, sales revenue is assumed to be linear in terms of quantity of the units sold. Also in traditional CVP analysis, costs are sharply categorized as fixed or variable with respect to the number of units sold. Therefore, under traditional CVP analysis, variable costs increase only as the number of units sold increases (Hilton, 2000:312). Nevertheless, traditional approach is consistent with the traditional product-costing systems, in which cost assignment is generally based on one or more volume-based cost drivers.

The use of Activity-Based Costing (ABC) helps researchers realize that there are some activities, costs of which change in proportion to some cost drivers other than sales volume. For example, batch-level activities such as set up, material handling, receiving and inspection, and quality assurance are performed for the production of each batch of products rather than a single unit. This means, as one more batch of products is produced, one more set up –or another batch level activity— is required. In this case, the production of each batch leads to an increase in the set up costs. Therefore, whereas the costs of batch-level activities are fixed with respect to the sales volume, they are not fixed with respect to other cost drivers, such as number of set up activity.

Under the traditional costing systems, however, costs are categorized as fixed or variable with respect to the number of units sold. Thus, traditional cost-volume-profit analysis treats setup, inspection, material handling, and similar activity costs as fixed costs because they are fixed with respect to number of units sold (Hilton, 2000:459). By contrast, ABC system does not treat these activities and their costs as fixed. This different treatment of the ABC system results in a difference in the CVP analysis performed under both systems. Therefore the aim of this paper is to demonstrate that traditional approach to CVP analysis may be misleading for management purposes.

This paper will be divided into three sections. In the first section, traditional cost-volume-profit analysis will be explained. In the second section, activity-based costing will be examined, and in the last, in which a new model is produced, the traditional and activity-based cost-volume-profit analysis will be compared to show the underlying causes of the differences.

1. Traditional Cost-Volume-Profit Analysis

Cost-Volume-Profit analysis is a study of investigating the relationships among sales volume, expenses, revenue, and profit. This technique summarizes the effects of changes in an organization's volume of activity on its costs, revenue, and profit (Hilton, 2000:290). Managers of profit seeking organizations study the effects of output volume on revenue (sales), expenses (costs), and net income (net profit). Therefore, this study is known as cost-volume-profit analysis (Horngren et.al., 2002:47). With the help of CVP analysis, management accountants are able to determine the effect of producing and selling one more unit on costs, revenue and profit. In addition, the effects of price and cost changes on profit can also be studied with the help of the CVP analysis. The starting point in studying CVP analysis is to outline underlying traditional assumptions since the analysis should be based on these assumptions.

1.1. Traditional CVP Assumptions

Traditional CVP analysis is based on several assumptions. These assumptions can be listed as follows (Horngren et.al, 2000:60):

a. Number of units of products produced is the only revenue and cost driver. In other words, only an increase in the number of units of products produced and sold causes increase in level of revenues and costs.
b. Total costs are divided into a fixed component and variable component that is variable with respect to volume of output.
c. Selling prices are constant within the relevant range, productivity is constant within the relevant range, and variable cost per unit is constant within the relevant range.
d. Traditional cost-volume-profit analysis covers a single product. When traditional CVP analysis covers multiple products, it assumes that sales mix will remain constant as the total number of units sold changes.
e. Fixed costs are fixed within the relevant range. Relevant range is the limit of cost-driver activity level within which a specific relationship between cost and cost driver is valid. Although fixed costs are unchanging with respect to cost driver (only volume-based cost driver), this rule is true only within reasonable limits. For example, rent costs, which are generally fixed, will rise if increased production requires additional building.
f. All units produced are sold.

All of the assumptions listed above establish the fundamentals of CVP analysis. Therefore in this paper, study of the traditional CVP analysis will be based on these assumptions. However, in the third section in which traditional and activity-based CVP analysis are compared, some of the above assumptions will be abandoned and some new assumptions will be established. The following paragraphs demonstrate the differences between variable and fixed costs. Since the effect of a change in output volume on cost and profit is based on the cost behavior, difference between variable costs and fixed costs should therefore be identified.

1.2. Difference Between Variable and Fixed Costs

A variable cost is a cost that changes in direct proportion with changes in the cost driver activity. In this case, cost driver represents any output measure that causes costs (Horngren et.al.,2002:43). For example, as one more unit of product is produced we need to use one more unit of direct material. Therefore, cost of direct material is a variable cost and number of units produced is the cost driver. However, as the number of cost-driver activity changes, there will be no change in the unit variable cost although total variable cost will change in direct proportion with the cost driver activity.

On the other hand, fixed costs are not affected by a change in the cost-driver level. For example, factory building insurance is a fixed cost. If the number of product units is the cost driver, increase in the number of units will cause proportional increase in the variable costs. However, there will be no change in the cost of insurance of the factory building. If the difference between variable and fixed costs is clearly identified, the effect of production volume on the costs, revenues and net income can easily be examined.

Under traditional approach, only total revenues and total variable costs change as a result of a change in the number of units purchased and sold. By contrast, fixed costs such as factory rent or depreciation costs remain the same regardless of the number of units purchased and sold. Therefore, as one more unit is purchased and sold, contribution to profit is the difference between unit selling price and unit variable cost. This difference between selling price and variable cost per unit is called unit contribution margin.

Contribution margin is the key concept in cost-volume-profit analysis. As one more unit is sold, fixed costs are covered by the amount of contribution margin. Once fixed costs are fully covered, contribution margin contributes to profit. In this case, management accountants can determine how many units of product must be sold to fully cover the fixed costs. In addition, managers can determine how many units to sell to reach the budgeted profit after covering the fixed costs. Furthermore, managers can examine how a change in price level, variable unit costs, and fixed costs will influence number of units that must be produced and sold to breakeven and to reach target profit. In the following section, it is explained how managers can use CVP analysis to make such decisions.

1.3. The Break-Even Point

The basic cost-volume-profit model can be used to find the break-even point, namely, the volume of activity that produces equal revenues and costs for the company (Upchurch, 1998, 168). Break-even point is the level of sales at which revenue equals expenses and net income is zero. Because company has no profit or loss at break-even point, it breaks even. Therefore, the study of cost-volume-profit relationships is often called break-even analysis (Horngren et.al., 2002:48). Break-even analysis is usually used for planning decisions. That is, with the help of break-even analysis, managers can determine how many units of product to produce and sell to break even at estimated fixed costs, variable costs, and the price level. Besides, they can identify how many units to sell to achieve planned level of profit. In this case, managers can plan all of the activities according to the results of break-even analysis because they know how decisions will influence revenue, costs and net income. Furthermore, managers are interested in break-even point mainly because they want to avoid operating losses because breakeven point tells them the level of sales they must generate to avoid a loss (Horngren et.al, 2000: 63).

In this paper, break-even analysis is based on estimated costs. In addition, estimated costs represents only the production costs. Therefore, profit represents operating profit throughout the paper. Break-even point can be calculated by using the following equation:

$$Break-even\ point = \frac{Fixed\ costs}{Unit\ contribution\ margin}$$

As explained before, selling of one unit of product recovers fixed costs by the amount of contribution margin. Therefore, if total fixed costs are divided by unit contribution margin, number of units of products that must be sold to cover fixed costs can be calculated.

1.3.1. Target net profit

Since the break-even point is the number of units required to earn a net profit of zero, each additional product sold will contribute toward profit. Therefore, number of units that should be sold to achieve a target profit can be calculated with the help of break-even analysis. When managers determine number of units to achieve a target profit, they should plan all of the activities accordingly.

To find the level of sales necessary to cover fixed costs and make a pre-specified profit requires a knowledge of selling price per unit, variable cost per unit, and the fixed costs together with the desired profit (Weetman, 1999 :689). In this case, the formulae given earlier to calculate break-even point can be modified to calculate number of units to reach target profit as follows:

$$\frac{(Fixed\ expenses + Target\ net\ profit)}{Unit\ contribution\ margin} = Number\ of\ units\ required\ to\ earn\ target\ profit$$

1.3.2. Safety Margin and Sensitivity analysis

Companies can determine the safety margin at expected production level. The safety margin is the difference between budgeted sales revenue and break-even sales revenue (Hilton, 2000:299). The safety margin can provide managers with the information about how close the projected operations are to the break-even point.

Sensitivity analysis is a "what-if" technique that managers use to examine how a result will change if the original predicted data are not achieved or if underlying assumptions change (Horngren et al.,2000: 68). In fact, the sensitivity analysis is an approach to recognize uncertainty. In other words, managers can see the possibility that actual amount will deviate from the expected amount.

The sensitivity analysis tries to answer such questions as, "what will profit be if selling price per unit decreases by 8 percent?" or "what will profit be if variable costs per unit increase by 5 percent?". Using the sensitivity analysis, managers can examine the effect and interaction of changes in selling prices, variable costs per unit and fixed costs. Examples for these can be found in any cost accounting books.

1.3.3. The Use of Cost Drivers in the Traditional Approach

Traditional costing systems use single volume-based cost drivers to determine how costs behave. In this case, variable costs are assumed to change only in proportion to a change in volume-based cost drivers such as number of machine hours run, and number of units produced and/or sold. Therefore, all of the costs that do not change with respect to the volume-based cost drivers are accepted as fixed costs. Nevertheless, there are some costs that are variable with respect to some cost drivers other than volume-based cost drivers. For example, setup costs vary with respect to number of setups rather than the number of units of production. Although these costs are regarded as fixed with respect to single volume-based cost driver, they are not fixed with respect to the other cost drivers.

Since the traditional costing systems are based on single volume-based cost driver, they provide less than adequate information for managerial decision-making (Cokins, 1999:37). This means that the traditional cost accounting systems do not supply reliable product cost information (Johnson, 1990:4). Therefore, traditional CVP should be abandoned in the existence of activities that are driven by cost drivers other than sales volume. In this case, use of activity-based CVP analysis can provide managers with better information because activity-based CVP analysis uses multiple cost drivers.

Before explaining activity-based CVP analysis, nature of activity-based costing should be examined in order to identify how single volume-based cost driver misleads managers in estimating costs for coming periods.

2. Activity-Based Costing

Activity-based costing is an extension of traditional volume-based costing that treats manufacturing overhead as a complex set of costs with multiple cost drivers (Mansuy, 2000:7; Drake et al., 2001: 444). Activity-based costing is a costing system that focuses on individual activities as the cost objects. An activity is an event, task or unit of work with a specified purpose; for example, designing products, starting up machines, operating machines, moving and distributing products (Hicks, 1999: 41). Under activity-based costing system overhead costs are accumulated in activity-cost pools in proportion to the organization's resources that are consumed with each activity. Then, overhead costs that are accumulated in the activity-cost pools are allocated to products based on appropriate cost drivers (McKenzie, 1999:56; Cooper and Kaplan, 1988:21; Baxendale, 2001:63).

A cost driver is a characteristic of an event or activity that results in the incurrence of costs (Hilton, 2000: 170). On the other hand a cost-driver base is a measurable cause, or driver, of performing an activity. For example, overhead costs accumulated in setup-cost pool can be allocated to products based on the number of setup activity performed for each product type, because number of setups has the best cause-and-effect relationships with the incurrence of the setup costs. Therefore, number of setups is the cost driver for the setup-cost pool.

Since the main purpose of this paper is to examine nature of activity-based costing from a break-even analysis perspective, the use of ABC to allocate overhead costs to products is beyond the scope of this paper. Therefore, in this section, activity-based costing will be studied just to understand that there exist some costs that are variable with respect to some cost drivers other than the volume-based ones such as number of units produced and sold. In order to understand how costs vary in proportion with some cost drivers, rather than number of units produced, it should be understood how organization's resources are consumed by activities. A resource is anything that is a cost to business. Therefore, consumption of resources will lead to an increase in costs (McKenzie, 1999: 56). Different decisions to acquire any of the resources described above will cause different resources to be available to the organization. Decision about these resources will determine overall cost structure of the organization. All of the resources can be explained to belong within a hierarchy defined as unit, batch, product, and facility-level. These resources are consumed by the activities performed within the organization (Cooper and Kaplan, 1991: 131). Activities also may be classified as one of the following four types, depending on the kind of decision to use resources: unit, batch, product, and facility-level. (Drake et al., 2001: 444; MacArthur, 1993: 53; Tanış, 1998).

Unit-level resources and activities: Unit-level resources are used for each unit of product. In other words, as one more unit of product is produced, the usage of unit-level resources increases. Materials used for production, components used for each unit, and energy such as electricity are among the unit-level resources, because these resources must be consumed for every unit of products produced.

Unit-level activities, on the other hand, are performed for each unit of production. In other words, unit-level activities must be repeated every time when a one-more unit of product is produced. A decision to produce more units of products causes more unit-level activities. For example, machinery should be operated as more products are produced. Since unit-level activities are performed for each unit of production, they consume unit-level resources. For example, as one more unit is produced, more energy (which is unit-level resource) is required.

Batch-level resources and activities: Batch-level resources are used as a result of producing a group of similar products. For example, specialized labor of technicians, and materials necessary to setup the equipment every time a batch of products is produced can be regarded as batch-level resources.

Batch-level activities, on the other hand, are performed for each group or batch of similar products. A batch refers to a number of units of product that require the same setup, personnel, and equipment. For example, inspection, material-handling, moving, and setup activities are batch-level activities. These activities require the acquisition of batch-level resources. For example, every time machinery is setup, materials and other batch-level resources should be used. Therefore, number of setups can be a cost driver for setup-cost pool.

Product-level resources and activities: Product-level resources are required as a result of the decision to have a specific product line. Specialized equipment, software, and specialized labor of engineers required to design a product can be given as examples to product-level resources.

Product-level activities, on the other hand, are performed to support particular product line, regardless of the number of units and number of batches in that product line. By contrast, batch-level and unit-level activities are performed for each batch of products and for each unit of production respectively. Engineering activities can be given as an example to product-level activity because an engineering activity is performed for the entire product line, rather than for each batch or each unit. The product-level activities cause consumption of product-level resources. For example, specialized labor of engineers is required to design the products.

Facility-level resources and activities: Facility-level resources are necessary to provide a general capacity to produce the products. These activities are required the entire production process to occur. For example, operating a plant is a facility-level activity because the plant is necessary for the entire production process to be performed. Likewise, facility-level activities cause a consumption of facility-level resources.

As explained above, producing more units requires a proportional increase in the unit-level activities. By contrast, some activities are performed regardless of the number of units of products produced. For example, batch-level activities are carried out for each batch of products, rather than each unit.

Once the activities are classified, it can be identified how an activity consumes resources. In other words, cost-driver base for each activity can be determined in order to identify how costs are incurred in the activity-cost pools. An increase or decrease in the cost-driver base leads to an increase or decrease in the level of an activity performed (Hilton et al., 2000:160). In turn, the level of an activity influences the consumption of resources and, consequently the costs (Naughton and Joseph, 2001: 49). For example, number of design specifications can be regarded as a cost-driver base for the engineering activity because there is a direct cause-and-effect relationship between the number of design specifications and the incurrence of engineering costs. For another example, number of batches can be a cost-driver base for all batch-level activities because these activities are performed in direct proportion with the number of batches produced.

From the explanations given above, it is understood that volume-based cost drivers such as number of units of products produced are not the sole cost-drivers that drive costs. In other words, some costs that are accepted as fixed under traditional costing system are variable with respect to some other cost drivers such as number of batches of products and number of design specifications. Because activity-based costing uses multiple cost drivers, the use of activity-based CVP analysis will provide better estimation of the costs.

3. Comparison of Traditional and Activity-based CVP Analysis

The most important difference between conventional cost models and activity-based costing is the treatment of non-volume related costs (Griful and Carles, 2001: 135). Under traditional cost-volume-profit analysis, costs are categorized strictly as fixed or variable, with respect to number of products produced and sold. However, some costs that are fixed with respect to the volume-based cost drivers are not fixed with respect to the other cost drivers as explained in the previous sections.

Under these circumstances, traditional CVP analysis may not generate accurate predictions of how total costs behave. In order to overcome disadvantages of the traditional CVP analysis, predicting total costs will require multiple cost drivers such as the number of setups, number of output units, and the number of design specifications. This will be achieved by the use of activity-based CVP analysis.

Activity-based costing can create pools of the volume-related and non-volume related costs. Therefore, it is a better tool for reliable planning and decision-making (Soloway, 1993:69). A difference between the traditional and activity-based CVP analyses emerges from the fact that the two methods will give different estimation of costs because they use different costs drivers.

The following figure is assumed to represent the production-cost structure of a company in the current period (month) under the traditional costing system. It is also assumed that there are 100 batches and 20 number of design specifications in the current production process of this company.

Fixed costs	**Current month**
Inspection …………………………………………………………	**$3,000**
Moving…………………………………………………………..	**1,000**
Engineering …………………………………………………….	**2,000**
Setup ……………………………………………………………….	**500**
Insurance ……………………………………………………….	**1,500**
Rental cost of factory…………………………………………...	**1,000**
Property taxes…………………………………………………..	**500**
Total fixed costs………………………………………………...	**$9,500**
Variable costs per unit	
Materials ………………………….………………………………	**$30**
Energy (electricity) ……………….………………………………	**20**
Total variable cost per unit………………………………………	**$50**

Since the inspection, setup, moving, and engineering costs are fixed with respect to the volume-based cost drivers, they are listed under fixed costs along with facility-level costs (insurance, property taxes, and rental costs) under the traditional costing system. On the other hand, materials and energy costs are variable because they change in direct proportion to an increase in the number of volume-based cost drivers. If the current selling price is assumed to be \$150, break-even point can be calculated as follows:

$$Break-even\ point = \frac{Fixed\ costs}{Unit\ contribution\ margin} = \frac{\$9{,}500}{(\$150-\$50)} = 95\,units$$

This means that, company breaks even at 95 units in the current month. If that company, for example, is currently producing and selling 1,000 units, safety margin is \$135,750[1]. This amount also includes the profit (\$90,500) for the current period.

What will happen if this company wants to increase profit from \$90,500 to \$100,000 in the coming month? To do so, it should increase number of units of products produced and sold in the coming period. In this case, number of units that must be sold to achieve target profit of \$100,000 can be calculated as follows:

$$\frac{(Fixed\ costs + Target\ profit)}{Unit\ contribution\ margin} = \frac{(\$9{,}500 + \$100{,}000)}{\$100} = 1095\,units$$

This means that, if the company wants to reach a target profit of \$100,000, it should produce and sell 1095 units in the coming period. This can be true if the estimated fixed costs will be the same in the coming period. In other words, selling 1095 units is expected to yield \$100,000 profit only if fixed costs are still \$9,500, as previously estimated.

Under the traditional CVP analysis, the estimated fixed costs will remain the same for the coming period because only volume-based cost drivers are used in this analysis. In other words, a decision to increase the number of units produced and sold will not be expected to affect the fixed costs under the traditional CVP analysis. However, if number of batches that company is currently producing is not enough to produce 1095 units, number of production—runs should be increased in the coming period. Furthermore, managers may decide to increase the number of design specifications in order to improve the design of the products to be able to sell more. For example, number of design specifications might be increased from 20 to 30.

Decisions made to increase the number of units of products produced in the coming period will not affect the estimated facility-level fixed costs under the

[1] [(1000 units – 95 units) X (\$150)]

traditional CVP analysis. This is because additional production is to be made without increasing the production capacity of the factory. In addition, costs of the batch and the product-level activities are regarded as fixed with respect to the volume-based cost drivers under traditional CVP analysis. Therefore, original prediction of costs of the batch and the product-level activities will be the same. In this case, number of units that should be produced to reach the profit of $100,000 will hold true under the traditional CVP analysis.

Although costs of the batch and the product-level activities are seemed to be fixed with respect to the volume-based cost drivers, they are not so with respect to other cost drivers. Thus, under the activity-based CVP analysis, a decision made to increase the number of production runs and design specifications will cause an increase in the costs of the batch and the product-level activities. However, variable costs per unit will not change because unit variable cost is the same regardless of the number of units produced, number of batches produced, or number of design specifications. In this case, contribution margin per unit will not change in the coming period.

As a result, the original estimate of 1095 units will not produce the expected target profit, because costs will grow in direct proportion with the increases in the number of batches and design specifications. Therefore, more units should be produced to cover increased costs with the same contribution margin. Based on the all explanations made above, the prediction of costs for the coming (new) period under the traditional and activity-based CVP analysis can be shown in the following figure:

Traditional CVP Analysis			**Activity-Based CVP Analysis**	
	Current period (1000 units)	**New period (1095 units)**	**Current period (1000 units)**	**New period (1095 units)**
	$	$	$	$
Inspection	3,000	3,000	3,000	3,600
Moving	1,000	1,000	1,000	1,200
Engineering	2,000	2,000	2,000	3,000
Setup	500	500	500	600
Insurance	1,500	1,500	1,500	1,500
Rental cost	1,000	1,000	1,000	1,000
Taxes	500	500	500	500
Total	9,500	9,500	9,500	11,400

Cost per inspection activity = \$3,000 ÷ 100 = \$30
Cost per moving activity = \$1,000 ÷ 100 = \$10
Cost per setup activity = \$500 ÷ 100 = \$5
Cost per design specifications = \$2,000 ÷ 20 = \$100
Number of production runs in the current period = 100
Number of production runs in the new period = 120
Number of design specifications in the current period = 20
Number of design specifications in the new period = 30

Because the unit variable costs are not affected by the decision to increase production level, they are not included in the above table. As seen in the table, inspection, setup, moving, and engineering costs are estimated to be the same in both periods under traditional CVP analysis. This is because the traditional CVP analysis uses only volume-based cost drivers.

On the other hand, under an activity-based CVP analysis, these cost are expected to increase in the coming period because company is planning to increase number of production runs and design specifications. An increase in the number of production runs will increase the batch-level costs such as setup, moving, and inspection because they increase in direct proportion as the number of batches produced increases. For example, in the current period 100 batches are produced. In this case, setup cost per batch is \$30[2]. Therefore, in the coming period, the setup cost is expected to become \$3,600[3] since the number of batches produced will be increased from 100 to 120. Likewise, engineering costs are expected to increase from \$2,000 to \$3,000 because number of design specifications, that is the cost-driver base for the engineering costs, will increase from 20 to 30. In the current period, engineering cost per design specification is \$100[4]. In this case, the engineering costs in the coming period are expected to be \$3,000[5]. In addition, moving costs will increase from \$1,000 to \$1,200 and inspection costs from \$3,000 to \$3,600 because of the same factors that apply to setup costs.

Nevertheless, facility-level costs (rental costs, insurance costs, and property taxes) are expected to be the same in the coming period under both systems, because these costs are fixed within the relevant range in the new period. To sum up, although

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[2] (\$3,000 ÷100 batches)

[3] (\$30 X 120 batches)

[4] (\$2,000 ÷ 20)

[5] (\$100 X 30)

production capacity is to be the same in the coming period, costs of batch and product-level activities are expected to increase under the activity-based CVP analysis. By contrast, effects of multiple cost-drivers on costs of batch and product-level activities are ignored under the traditional CVP analysis.

Based on the above table, break-even point for the new period can be calculated under the traditional and activity-based CVP analysis as follows:

Traditional cost-volume-profit analysis

Fixed costs in the coming period are expected to be $9,500 as seen in the above table. In addition, since unit price and variable costs per unit will not change in the coming period, unit contribution margin per unit will be the same, that is $100. In this case, break-even point can be calculated as follows:

$$Break-even\ point = \frac{Fixed\ costs}{Unit\ contribution\ margin} = \frac{\$9{,}500}{\$100} = 95\ units$$

This means that break-even point is expected to be the same in coming period as well. That is, if the company is planning to increase production to 1095 units, it will generate target profit of $100,000[6]. Therefore, if managers use traditional CVP analysis, they are convinced that producing and selling 1095 units will yield a target profit of $100,000. However, the managers are going to see that production of 1095 units will not produce $100,000 target profit if they use activity-based CVP analysis.

Activity-based cost-volume-profit analysis

Under the activity-based CVP analysis, facility-level costs are expected to be the same in the coming period because production capacity is expected to be the same. However, costs of batch and product-level activities are expected to increase because of the reasons explained in the previous sections. In this case, break-even point will be different in the new period because more products should be produced and sold to cover the increased costs with the same contribution margin.

Under the activity-based CVP analysis, fixed costs should be divided into two cost items. The facility-level costs which are really fixed within the relevant range and product-level and batch-level costs that are fixed with respect to the volume-based cost drivers, but variable with-respect to other cost drivers such as the number of batches produced (all of which costs are considered as fixed in the traditional approach).

This requires that the estimated facility-, batch-, and product-level costs be covered in full to breakeven in the coming period. Then, every additional unit will

[6] [(1095 units – 95 units) X $100]

contribute to profit by the amount of contribution margin. Therefore, more number of units should be produced and sold to reach the target profit. Using these explanations, a new model of CVP, in which a break-even formulae is produced under the activity-based principles should be modified as follows:

$$Break-even\ po\text{int} = \frac{Facility-level\ fixed\ \text{costs} + [Batch\ \text{cost} \times Batch\ CDA + \text{Pr}oduct\ \text{cost} \times \text{Pr}oduct\ CDA]}{Unit\ contribution\ \text{margin}}$$

Where,

CDA = Cost driver activity such as the number of batches and the number of design specifications.

In the above formulae, unit contribution margin is the difference between selling price and variable cost per unit. Variable cost per unit is the unit-level costs for each unit, because unit-level costs increase in direct proportion with the number of units produced. Therefore, every additional unit will cover expected facility, batch, and product-level costs with the amount of unit contribution margin that is equal to the difference between the unit price and unit-level costs per unit. In this case, break-even point for the coming period under activity-based CVP analysis can be computed as follows:

$$Break - Even\ Po\text{int} = \frac{\$11{,}400^{*}}{\$100^{**}} = 114\ units$$

****Total of expected facility, batch, and product-level cost for the new period (Rental costs, insurance costs, property taxes, setup costs, inspection costs, moving costs, and engineering costs). Where,***

Rental costs = $1,000

Insurance costs = $1,500

Property taxes = $500

Setup costs = Setup cost X number of setups = $5 X 120 = $600

Inspection costs = Inspection cost per batch X number of batches = $30 X 120 = $3,600

Moving costs = Moving cost per batch X number of batches = $10 X 120 = $1,200

Engineering costs = Engineering cost per design specification X number of design specifications

= $100 X 30 = $3,000

***** Contribution margin = Unit price – Variable costs per unit = $150 - $50= $100***

Whereas the break-even point requires a production of 95 units under traditional CVP analysis, it is found as 114 units when activity-based CVP analysis is employed. In this case, the original prediction of 1095 units will not yield the target profit of $100,000. Under the activity-based CVP analysis profit will be $98100[7], if the company produces and sells 1095 units

If the company performs a total production of 120 batches, and a number of design specifications 30, it will generate $98,100 rather than a profit of $100,000 in the coming period. Therefore the managers, employing the traditional CVP analysis, will become disappointed because they are not able to reach a target profit of $100,000 if they produce and sell 1095 units.

Activity-Based Sensitivity Analysis

Sensitivity analysis, under the activity-based CVP analysis, can be performed to see how a change in price level and unit variable costs will influence break-even point and the number of units that should be produced to reach a target profit. In addition, the sensitivity analysis can be conducted to determine how a change in multiple cost drivers will influence estimated revenues, costs, break-even point, and number of units that must be sold to achieve the target profit.

Therefore, the activity-based sensitivity analysis can answer such questions as, "what will break-even point be if number of production runs are increased by two batches?", or "what will profit be if number of design specifications is increased?". In this case, effects of changes in multiple cost drivers should be examined.

For example, managers can perform sensitivity analysis in order to estimate the number of units for break even if the number of production runs will be 130 instead of 120 in the new period.

[7] (1095 – 114) x $100

Activity-Based Sensitivity Analysis		
	Original Estimate of costs (120 Batches)	**New Estimate of Costs (130 Batches)**
	$	$
Inspection	3,600	3,900
Moving	1,200	1,300
Engineering	3,000	3,000
Setup	600	650
Insurance	1,500	1,500
Rental cost	1,000	1,000
Property taxes	500	500
Total	11,400	11,850
Cost per inspection activity = $30 **Cost per moving activity = $10** **Cost per setup activity = $5**		

As seen from the above table, if the number of batches is increased from 120 to 130, the batch-level costs such as setup, moving and inspection are expected to increase proportionally. For example, the setup costs increase from $600 to $650[8]. On the other hand, the engineering costs are expected to be the same, because number of design specifications remains the same. In the same way, facility-level costs do not change because production capacity is assumed to be the same.

Thus, break-even point with the new estimation of the costs can be calculated as follows:

$$Break-even point = \frac{[Facility-level costs + Batch-level costs + Product-level costs]}{Unit unit contribution margin} = \frac{\$11,850}{\$100} = 118 units$$

As seen, if the number of production runs is increased from 120 to 130, break-even point is estimated to be 118 units for the coming period. Because, as the more units will be required to cover increased batch-level costs, the more units should be produced and sold to reach the target profit.

[8] ($5 X 130)

As a result, managers realize that a decision to increase batch-level activities or product-level activities will influence the expected cost structure. Nevertheless, the use of the traditional CVP analysis will not give accurate predictions of costs. Therefore, the activity based CVP analysis should be employed to have better information for the decision-making process.

Summary and Conclusion

The traditional cost-volume-profit analysis uses only volume-based cost drivers such as the number of units produced. Therefore, costs are categorized as fixed or variable with respect to the number of units of products produced. All of the costs that do not change with respect to sales volume are accepted as fixed under the traditional CVP analysis. However, there are some costs such as the batch-level and product-level costs that are fixed with respect to volume-based cost drivers, but variable with respect to other cost drivers, rather than production volume. In this case, the use of the traditional CVP analysis will be misleading for managerial decision-making process because it will not provide managers with the correct prediction of costs. By contrast, the activity-based CVP analysis will use multiple cost drivers to estimate the costs for the coming periods. Hence, the activity-based CVP analysis will provide better prediction of costs and much more complete picture of break-even analysis. Therefore, just as activity-based costing was shown to improve cost management and decision-making, it also produces organizational benefits when coupled with CVP model.

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