Assessment of Product Profitability

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Abstract
Activity-based costing literature has emphasized accurate cost assignment but management of product profitability must consider other aspects, too. This paper will especially discuss how the choice of the profitability measure can affect our impression of product profitability. A truly anticipatory system should also be able to estimate customer behavior, because both revenue and cost affect profitability. These aspects will be illustrated with examples.
Keywords: product profitability, activity-based costing, product costing, pricing, economic profit

1 Introduction

Activity-based costing can significantly increase understanding of product profitability by providing more accurate product costs. Typically, special products that were believed to be highly profitable reveal to be much more expensive to produce. These kind of new insights can lead the firm to revise its product mix and pricing or take other actions to improve profitability. Accurate cost assignment usually gets the most attention in assessing product profitability, and operating profit is the typical measure for product profitability.

Return on investment (ROI) in some form has been a typical measure of profitability at company level. In the late 1980s, several financial consulting firms published studies that showed a high correlation between the changes in companies' economic profit and changes in their stock market valuation. In short, economic profit is operating profit after taxes less capital charge based on weighted average cost of capital (WACC) and capital invested in the business. Residual income and economic value added belong to the same category of profitability measures as economic profit. Economic profit is an important measure because it combines size and return on investment into a single result. Focusing on size could destroy value if returns on capital are too low. Conversely, earning a high ROI on a low capital base may mean missed opportunities. In theory, one should maximize economic profit but not ROI percentage.

Measures like economic profit have received more emphasis over ROI, and in the late 1990s, authors like Kaplan & Cooper (1998, 265-267) or Kee (1999) have suggested that economic profit should be integrated with activity-based costing (ABC) when assessing product profitability. This paper analyzes how the choice of the product profitability measure can affect the anticipatory capabilities of a firm's cost accounting system and consequently a firm's decision-making.

2 Ranking Products by Profitability

Advocates of economic profit approach have usually demonstrated the difference to operating profit approach with a simple example similar to the one expressed in table 1. A firm has an established product A and two complementary products B and C. As a whole the firm is profitable because its return on investment (ROI= Operating profit / Capital employed) exceeds the weighted average pretax cost of capital 14,08 %. The weighted average pretax cost of capital is calculated by adjusting the weighted average cost of capital by tax rate [14,08 % = 10 % / (1 - 0,29)].

Table 1: different measures of product profitability

Product	A	B	C	Total
Sales volume (units)	10000	1000	1000	
Unit price	104,00	103,50	104,50	
Revenue	1040000	103500	104500	1248000
Materials	600000	70000	50000	720000
Operating costs	400000	30000	50000	480000
Operating profit	40000	3500	4500	48000
Taxes (29%)	11600	1015	1305	13920
Capital charge (10%)	28250	2199	3284	33733
Economic profit	150	286	-89	347
ROS-%	3,85 %	3,38 %	4,31 %	3,85 %
Working capital	82500	6993	7840	97333
Fixed assets	200000	15000	25000	240000
Capital employed	282500	21993	32840	337333
ROI	14,2 %	15,9 %	13,7 %	14,2 %

If one uses operating profit or return on sales percentage (ROS-% = Operating profit / Revenue) as a measure of product profitability, the order of products is C, A, B. The large volume of product A makes it the most important product. On the other hand, if we use economic profit (EP) as a measure of product profitability, the rank order changes. Now product C proves to be unprofitable whereas product B becomes the most profitable product. Product-level ROI gives the same rank order of products as economic profit but each product's importance in total profitability is more difficult to interpret.

Let us assume that the demand of product A would start to decrease and the demand of product C would start to rise in proportion. If our knowledge of product profitability lies on operating profit calculations, this kind of trend would seem favorable to the total profitability. The owners of the company would not be happy, however, since the capital-intensive product C would erode the economic profit and the value of the company. ROS percentage of products would not alarm the management beforehand.

Information of product profitability can be used in various decision-making situations. Management could decide to eliminate the unprofitable products and invest more one the profitable ones. Another basic alternative is to raise prices on unprofitable products. In practice, one can always use combinations of these elementary solutions. Many products are expensive because of poor product designs. Redesigning products offers an attractive option because it will usually be invisible to customers. If the redesign is successfully done, a company does not have to re-price or eliminate products.

Target costing is a discipline that ensures that new products are designed to be profitable. The first step in target costing is to determine a product's target selling price and target profit margin. The typical measure of profitability seems to be operating profit or ROS percentage. However, according to Cooper and Slagmulder (1997, 102) firms with products that require large up-front investments carry out life-cycle analyses so they can set target profit margins large enough to ensure that the products earn an adequate profit margin over their life. Suematsu (2000) suggests cash-flow costing to be applied in target costing. In this approach, the present value of target profit and the present value of all cash outflows must be equal to the present value obtained from the sale of the product. Therefore, it seems that value-based approach is not neglected in target costing although measures like economic profit or economic value-added are not directly mentioned.

3 Pricing

Over the long run, companies need to price their products so that they recover all of the resource costs and obtain an adequate return on invested capital. This goal suggests that the profit percentage markups over costs should be a function of the invested capital required by individual products. Such invested capital would include long-term assets and working capital, especially inventory and accounts receivable, used by products.

Target return-on-investment (ROI) pricing is intuitively appealing because it relates price not only to the operating expenses of product development and manufacturing but also to the capital investment required for the production and distribution of the product. Second, target ROI pricing provides some stability to a company's pricing policies. When activity cost driver rates and investment are based on practical capacity, prices will not fluctuate with short-term changes in actual sales. The target ROI approach also provides a defensible price, permitting the company to cover its costs and earn a competitive return on its invested capital. (Kaplan & Atkinson 1998, 156-157)

The formula used to calculate the price (x) in target ROI pricing is expressed in eq. 1. The symbol w denotes the target value for return on investment. Other symbols are explained in table 2. A similar formula is also presented by Kaplan and Atkinson (1998, 156), although it does not specify the drivers of working capital.

$$x = m + c + \frac{w(m\frac{d}{356} + c\frac{r}{365} + \frac{1}{2}ic\frac{l}{365} + a)}{1 - w\frac{r}{365}} \qquad (1)$$

Table 2 presents the drivers of product cost used in the calculations in table 1. ROS calculations apply only material and operating cost whereas EP and ROI calculations apply all the drivers. With this cost driver data, we can analyze various situations and compare the different profitability measures.

Table 2: drivers of product costs

Product	**A**	**B**	**C**
Materials per unit (*m*)	60,00	70,00	50,00
Operating cost per unit (*c*)	40,00	30,00	50,00
Unit cost	100,00	100,00	100,00
Inventoriable costs (*i*)	50 %	50 %	50 %
Receivables days (*r*)	30	30	30
Payables days (*p*)	-25	-25	-25
Materials turnover days (*k*)	5	5	5
Lead time days (*l*)	15	15	15
Cash-to-cash cycle ($d= r+ p+ k +l$)	25	25	25
Fixed assets per unit (*a*)	20,00	15,00	25,00

Table 3 illustrates ROI pricing using the same products as table 1. It is assumed that the demand of product A decreases to 8000 whereas the demand of product C is doubled. Changes in demand are caused by changes in the size of the market, not by pricing decisions.

Naturally, ROI pricing suggests a price that guarantees the target ROI for each product. If the target value for ROI (in this case 14,2%) is greater than the weighted average pretax cost of capital, each product should make economic profit. A higher ROS percentage is set for more capital-intensive products.

Table 3: example of target ROI pricing

Product	A	B	C	Total
Sales volume (units)	8000	1000	2000	
Unit price	104,00	103,25	104,75	
Revenue	832000	103250	209500	1144750
Materials	480000	70000	100000	650000
Operating costs	320000	30000	100000	450000
Operating profit	32000	3250	9500	44750
Taxes (29%)	9280	943	2755	12978
Capital charge (10%)	22600	2294	6711	31606
Economic profit	120	13	34	167
ROS-%	3,85 %	3,15 %	4,53 %	3,91 %
Working capital	66000	7944	17111	91056
Fixed assets	160000	15000	50000	225000
Capital employed	226000	22944	67111	316056
ROI	14,2 %	14,2 %	14,2 %	14,2 %

In ROS pricing we assume that each product's ROS-% should be the same. The average target operating profit is derived from the target rate of return on investment and from the previous period's figures as expressed in equation 2. Because the sum of material and operating cost is the same for all products, ROS pricing would suggest that the price for each product should equal 104,00.

$$ROS\_target = \frac{ROI\_target \times Capital\_employed}{Revenue} \qquad (2)$$

Table 4 illustrates the consequences of ROS pricing in our numerical example. Product C creates operating profit but destroys economic profit. Deteriorating overall profitability could lead the firm to increase its targeted ROS-percentage and to update prices. This would probably cause more problems in the form of decreasing market share.

Table 4: example of ROS pricing

Product	A	B	C	Total
Sales volume (units)	8000	1000	2000	
Unit price	104,00	104,00	104,00	
Revenue	832000	104000	208000	1144000
Materials	480000	70000	100000	650000
Operating costs	320000	30000	100000	450000
Operating profit	32000	4000	8000	44000
Taxes (29%)	9280	1160	2320	12760
Capital charge (10%)	22600	2301	6699	31599
Economic profit	120	539	-1019	-359
ROS-%	3,85 %	3,85 %	3,85 %	3,85 %
Working capital	66000	8007	16986	90993
Fixed assets	160000	15000	50000	225000
Capital employed	226000	23007	66986	315993
ROI	14,2 %	17,4 %	11,9 %	13,9 %

One could also try to set a target product mix and calculate the average ROS target using the forecasted income statement and balance sheet. In order to forecast the capital invested accurately, one should have detailed information of capital requirements for different products. Without this information, the estimate of capital employed is based on historical averages. With this information, one could apply the target ROI approach as well. Furthermore, the ROI approach would be more reliable than ROS pricing, because the average ROS-target is sensitive to forecasting errors in the expected product mix.

4 Price-quantity Tradeoffs

Any pricing method will be dysfunctional if it encourages an inward viewpoint by the company. Competitive and demand elasticity considerations may be suppressed when little consideration is given about whether targeted volumes can be achieved with the price calculated by a cost-based formula. Thinking about the demand curve for the company's products is a useful exercise because it focuses managers' attention on the external environment in which products must be sold. Techniques for estimating demand curves have been developed and have been applied for standard products such as agricultural commodities, automobiles and alcoholic beverages. The techniques have been applied, however, mostly to aggregate demand at the industry level. They have been rarely applied to estimate the demand curves for the products of an individual company. (Kaplan & Atkinson 1998, 152-153) In the next section, a simple method is suggested to anticipate the importance of price-quantity tradeoffs.

4.1 Estimating the Demand Curve

A firm has a limited freedom in pricing its products. Higher prices decrease the overall demand or market share. If price is not the only input into a customer's purchasing decision, such elements as product differentiation and brand image may give a firm more upward pricing freedom with some customer segments. Setting the price too low would probably hurt the product's image. A firm must also recognize the potential reactions of competitors to price changes. Competitive reactions by producers of substitute products, if major price changes were implemented, could upset the calculations of forecasts embedded in a calculated demand curve.

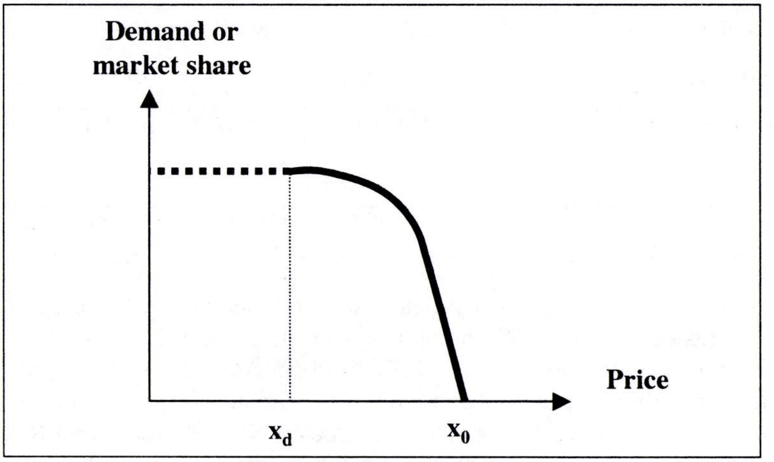

Fig 1: freedom of pricing

Figure 1 illustrates the freedom of pricing. The minimum price (x_d) and the maximum price (x_0) determine the relevant range of the demand curve. Setting the price below x_d would lead to serious counteractions by competitors, and the assumptions of market share are no longer valid. Therefore, the maximum market share is reached at this point.

Next, let us estimate the demand for a product with an equation of the second order. If the freedom of pricing is wide, an equation of second order may not be the best choice. However, it is simple to use and the price range is usually quite narrow. Therefore, it describes well enough the non-linearity of a demand curve. In eq. 3, symbol S denotes market share, x denotes unit price, and *a*, *b* and *c* are parameters to be adjusted.

$$S(x) = ax^2 + bx + c \quad (3)$$

Considering the shape of the demand curve, we know that $a<0$. S(x) has a unique maximum at x_d where $S'(x_d)=0$. Now we can write eq. 4, and notice that $b \geq 0$ because x_d can not be a negative value.

$$x_d = -\frac{b}{2a} \quad (4)$$

There are two possible solutions for S(x)=0 as we can see from eq. 5a, but we are interested in the greater value. We know that $-b/2a \geq 0$ and since we are not interested in imaginary numbers $\sqrt{b^2 - 4ac} \geq 0$. Therefore, we can solve the maximum price (x_0) from eq. 5b.

$$x_0 = -\frac{b}{2a} \pm \frac{\sqrt{b^2 - 4ac}}{2a} \quad (5a)$$

$$x_0 = \frac{-b - \sqrt{b^2 - 4ac}}{2a} \quad (5b)$$

A firm has a pricing freedom between values x_d and x_0. A measure of the pricing freedom is n, which is the ratio of x_0 to x_d. Next, we normalize the demand curve by substituting x_d for 1, which simplifies the calculations because we can write $b= -2a$. If we know x_0 and x_d, we can solve c as a function of a from eq. 6. If we also know $S(x_d)$, we can solve c using eq. 1 and get $c = S(x_d)+ a$. Now we have two ways to determine c and we can write eq. 7 to solve a. Thereafter we can calculate parameters b and c in eq. 3. We can also ensure that $b^2 - 4ac \geq 0$.

$$n = \frac{x_0}{x_d} = \frac{-b - \sqrt{b^2 - 4ac}}{-b} \quad (6)$$

$$S(x_d) + a = -a(n^2 - 2n) \Leftrightarrow a = \frac{-S(x_d)}{(n-1)^2} \quad (7)$$

We can now return to our numerical case and compare ROS approach and ROI approach once again. Let us assume that the pricing freedom (n) of each product is 1,05 and the maximum market share (S) is 20%. In this case, a equals -80, b equals 160 and c is -79,8.

4.2 Optimum Price

In principle, a firm should set the price to maximize profit. Once again we have to choose the measure of profit. A general equation for profit (P) is expressed in eq. 8 where v denotes unit cost. We can also formulate eq. 9 for the price that maximizes profit.

$$P(x) = (x - v) \cdot S(x) \tag{8}$$

$$x_{max} = \frac{va - b}{3} \pm \sqrt{\frac{b^2 + vab + v^2a^2 - 3ac}{9a^2}} \tag{9}$$

Naturally, x_{max} equals x_d only if v is zero. A more important notion is that x_{max} depends on our definition for unit cost. Marginal costing approaches would emphasize sales volume or market share whereas full costing approaches would lead to smaller target market share. Similarly, economic profit and operating profit will lead to a different optimum price.

In case we want to maximize economic profit, unit cost must be total economic unit cost, i.e. the sum of total operating costs and a charge for capital. The equation for profit can be expressed as in eq. 10 where r denotes weighted average pretax cost of capital and C denotes capital employed.

$$P(x) = (x - v - rC) \cdot S(x) \tag{10}$$

If we assume C to be independent of x, we can substitute v for v+rC in eq. 9. This assumption is not valid, however, because x affects the accounts receivable, which is part of capital employed. So the formula does not give the exact optimum but it is close enough for our purposes.

In table 5, the assumed demand curve is used to estimate the market share and volume in three cases: starting case (table 1), optimum using operating profit and optimum using economic profit. Optimum prices for products are derived from eq. 9 where the term (m+ c) or (m+ c+ rC) is substituted for v.

Table 6 presents the situation where the firm has assessed product profitability by operating profit. Product prices are derived from eq. 9, and v includes material and operating costs.

Table 7 presents a situation where economic profit is the measure of product profitability. If we compare table 6 and table 7 we see that target ROI pricing leads to a better outcome with higher economic profit. This is conceptually evident, if we prefer economic profit for operating profit as the overall measure of a firm's profitability. It should also be noticed that understanding customer's price sensitivity is crucial to profitability. Both ROI and ROS based optimum prices lead to significantly higher profits than the merely cost-based prices calculated in tables 3 and 4.

Table 5: sales volumes for different prices

	Product	A	B	C
	Total demand	40000	6000	10000
Starting case	Price	104,00	104,00	104,00
	Market share	20,0 %	16,6 %	20,0 %
	Sales volume (units)	7989	997	2000
Optimum using operating profit	Price	105,79	104,28	108,24
	Market share	17,1 %	15,7 %	18,3 %
	Sales volume (units)	6830	939	1826
Optimum using economic profit	Price	106,86	105,32	109,17
	Market share	13,1 %	11,0 %	15,6 %
	Sales volume (units)	5231	660	1561

Table 6: maximizing operating profit

Product	**A**	**B**	**C**	**Total**
Revenue	722546	97919	197646	1018111
Materials	409800	65730	91300	566830
Operating costs	273200	28170	91300	392670
Operating profit	39546	4019	15046	58611
Taxes (29%)	11468	1165	4363	16997
Capital charge (10%)	19397	2163	6180	27740
Economic profit	8681	691	4502	13874
ROS-%	5,47 %	4,10 %	7,61 %	5,76 %
Working capital	57366	7540	16154	81060
Fixed assets	136600	14085	45650	196335
Capital employed	193966	21625	61804	277395
ROI	20,4 %	18,6 %	24,3 %	21,1 %

Table 7: maximizing economic profit

Product	**A**	**B**	**C**	**Total**
Revenue	558985	69511	170414	798910
Materials	313860	46200	78050	438110
Operating costs	209240	19800	78050	307090
Operating profit	35885	3511	14314	53710
Taxes (29%)	10407	1018	4151	15576
Capital charge (10%)	14902	1526	5296	21723
Economic profit	10576	967	4868	16411
ROS-%	6,42 %	5,05 %	8,40 %	6,72 %
Working capital	44402	5357	13930	63690
Fixed assets	104620	9900	39025	153545
Capital employed	149022	15257	52955	217235
ROI	24,1 %	23,0 %	27,0 %	24,7 %

In order to calculate a price based using target ROI method, a firm must assign capital costs to products. Horngren et al. (1999, 393) state that companies sometimes find it difficult to determine the capital invested to support a product. Some companies therefore prefer to use alternative cost bases and markup percentages that do not require calculations of invested capital to set price. The examples presented in this chapter have demonstrated the importance of knowing capital invested to support a product. The benefits of improved information may well exceed the increase in cost of measurement.

Furthermore, Kaplan and Atkinson (1998, 522) as well as Kee (1999) find the assignment of many assets to individual products straightforward. Some assets, such as inventory, are already directly attributable to individual products. Dedicated assets, such as specialized production equipment, tooling and test equipment, can be assigned to the narrow range of products that use those resources. A wide range of products may use other assets. In this case, the asset assignment can be done with the same cost drivers used to drive operating expenses of the equipment to individual products.

5 Limitations and Further Considerations

This paper has demonstrated the problems related to the assessment of product profitability. Naturally, we cannot generalize any rules based on a single numerical example. Changing the product parameters easily alters the magnitude of differences. On the other hand, other authors have showed the superiority of economic profit over operating profit as an overall measure of profitability. The main focus in this paper has been in illustrating the consequences of using different profitability measures.

The point of view has been on long-term product profitability. Activity-based costing (ABC) reflects the cost of resources necessary to produce a product independent of the level of its production or the level of resources supplied for its production. ABC measures the long-term cost of the resources used to produce a product as well as the cost of the individual activities used in its production. It was assumed in the example, that a firm has an accurate activity-based costing system and all resources are totally flexible.

Focusing on product profitability using activity-based costing is a long-term approach that considers each product separately. Total optimum is not reached by optimizing each product separately. Theory of constraints (TOC) applies optimization models to shape the product mix and it focuses on the effective utilization of production bottlenecks in the short run. TOC does not consider the impact of short-term decisions on long-term market dynamics and the requirements for maintaining an ongoing business. Schneiderman (2000) has emphasized the importance of managing system profit. His way to view product profitability combines ABC and TOC considerations and adds competition based market constraints to provide different strategies for long-term maximization of shareholder value.

6 Conclusions

This paper has emphasized the importance of economic profit as a measure of long-term product profitability. Typically, product costing systems consider only operating costs and they neglect the capital invested to support products. This omission can distort management's impression of profitability in the same way as arbitrary cost allocations. Assessment of product profitability is not only about measuring costs, though product cost accounting seems to get the most attention. Profitability is also linked to tradeoffs between price and volume.

A system that uses the historical product mix and average capital invested to determine target operating profit has weak anticipating capabilities. A modification of the system would use the anticipated future product mix and the corresponding capital invested. In this case, we must suppose that we can estimate the changes in product mix accurately. In practice, the product mix will change through a series of decisions and we cannot include every step in our model. In order to improve the accuracy of the system, a better approach would be to determine the cost of capital for each product and judge the product profitability with economic profit. This kind of a model is aligned with the assessment of a firm's total profitability and is likely to prompt the managers to make consistent decisions in time.

Generally, historical or forecasted future averages are poor estimates for future profitability but they are easy to use because one does not need very detailed input to calculations. Managers should reconsider the balance between the costs and benefits of measurement in accounting systems. First, economic profit could be incorporated in product group calculations.

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