ENGINEERING MANAGEMENT - GENERAL

LONG TERM DECISION-MAKING USING THROUGHPUT ACCOUNTING

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Abstract: Throughput accounting, the Theory of Constraints' alternative to product costing, is being criticised for ignoring fixed costs and emphasizing short-term optimization by assuming that variables such as product price, customer orders, technology and production design are fixed and therefore appropriate for maximizing throughput. It is argued that the Theory of Constraints and thus also throughput accounting are little more than a powerful short-run optimisation procedures.

This paper explores the underlying concepts of throughput accounting to demonstrate how short-term decisions are made using throughput accounting. The superiority of throughput accounting over traditional product costing is demonstrated using a simple case study. In the case study it is demonstrated that with the throughput accounting approach, a much better decision can be made to optimize the system as opposed to using traditional costing approaches. The false underlying assumptions of product costing are also being exposed.

This is followed by a real-world case study where a long-term decision is analyzed using both the traditional product costing/ management accounting approach and the throughput accounting approach. In this particular case, the management of the organization must make the decision whether to accept or reject an order with long-term investment implications. Using the traditional management accounting approach leads to one decision whereas using throughput accounting leads to the opposite decision. These two outcomes are compared and an analysis done as to why the differences in outcomes exist.

Key Words: Decision-making, long-term decisions, Theory of Constraints, throughput accounting.

I. INTRODUCTION

THROUGHPUT accounting is the Theory of Constraint's alternative to cost accounting (in whatever form – product costing, activity-based costing, full costing, absorption costing) for making management decisions with the aim to increase profitability. This aim is in line with the organizational system goal, namely to increase the profitability of the organization now and in the future. Necessary conditions to this goal, namely providing satisfaction to the market and looking after employees and suppliers [1], are for the purpose of this paper assumed to be in place. Therefore the decision making referred to imply decisions relating to the goal of the organization, and not the necessary conditions. It can thus be stated that the task of management is to make decisions that will benefit the organization as a whole and taking responsibility for those decisions.

Throughput accounting has been designed to do just that; allowing managers to make decisions that will increase the profitability of the organization and accepting responsibility for those decisions, as throughput accounting allows for transparency and visibility of the underlying data and principles on which the decision-making rests. There is however a reluctance to accept throughput accounting as a sound technique when it involves long-term decisions. The basis for the opposition to using throughput accounting for long-term decision making is based on the argument that throughput accounting ignores fixed cost and can only be used for short-term optimization by assuming that variables such as product price, labor costs, technology and the production system are fixed [2]. In a comparison of throughput accounting and activity-based costing (ABC), Holmen [3] states that it is clear that throughput accounting primarily has a short-run time horizon whereas activity-based costing primarily has a long-run time horizon. Holmen continues to say that in the longer run more and more costs (such as labor) are changeable, which makes activity-based costing more applicable than throughput accounting in these longer-term decisions. This paper will demonstrate that throughput accounting will provide better answers for both short-term decisions and long-term decisions.

II. THROUGHPUT ACCOUNTING'S SHORT TERM SUPERIORITY

A. Introduction

Throughput accounting's superiority over a product costing approach has been demonstrated numerous times. The most well known is the PQ product mix problem described by Goldratt [4]. Patterson [5] provides another excellent example demonstrating throughput accounting's superiority over labor-based management accounting. For the sake of clarity a simple PQ-like problem (adapted from Goldratt [4]) will be analyzed to compare the different decision-outcomes arrived at by using throughput accounting and activity-based costing.

B. Case data

Operations managers will provide many reasons why it is difficult to manage operations. Most of these reasons relate to variability within the operational system:

- On the supply side, suppliers deliver late; they deliver the wrong quantities; the quality is many times unacceptable and suppliers increase prices at will.
- Within the processes, processing times vary; employees are late / on strike / working too slow / insufficiently trained; equipment breaks down and the quality may be unacceptable.
- On the demand side, customers change their minds with regards to what they want, when they want it and the quantities they want; also price elasticity is not known.

Variability being common to the instances stated above, is many times singled out why an operational system is not performing well i.e. why bad management decisions are being made. It is assumed that the system variability makes it impossible to make a good decision that will benefit the organization as a whole. Many managers will also agree that making good decisions within operations will be much easier if there was no system variability. No wonder so many techniques (e.g. TQM, TPM, JIT and 20 keys) are all focusing on the elimination of system variability. However, with the case to be analyzed, it is assumed that there is no system variability, i.e. the case analyzed will consider the perfect organization, where everything is constant, predictable and free of variation. This perfect system is necessary to demonstrate that it is still very easy to make bad decisions even in a perfect system. This bad decision-making is the result of using decision-making techniques that are fundamentally flawed and cannot be attributed to system variability.

The demand and selling prices for the two products produced by the company is shown in Table I. Demand is constant and fixed and so is the selling price. An increase in any of the two selling prices will result in the demand drop to zero for both products, whereas a decrease in selling price will not result in an increase in demand for any product.

Table I
Demand and market information

	Demand	Selling price
Product X	60 units/week	R95–00/unit
Product Y	60 units/week	R105–00/unit

Processing and supplier information is provided in Fig. 1. Processing times are constant, supplier deliveries are instantaneous, quantities and the quality of deliveries are always correct, raw material prices are constant. The following additional information is provided:

- There are four resources, each performing two processes, which cannot run simultaneously.
- Resources cannot substitute for one another.
- Each resource has a fixed cost of R1 500.00 per week.
- Each resource is available for 2400 minutes per week (5 days/week X 8 hrs/day X 60 min/hr).

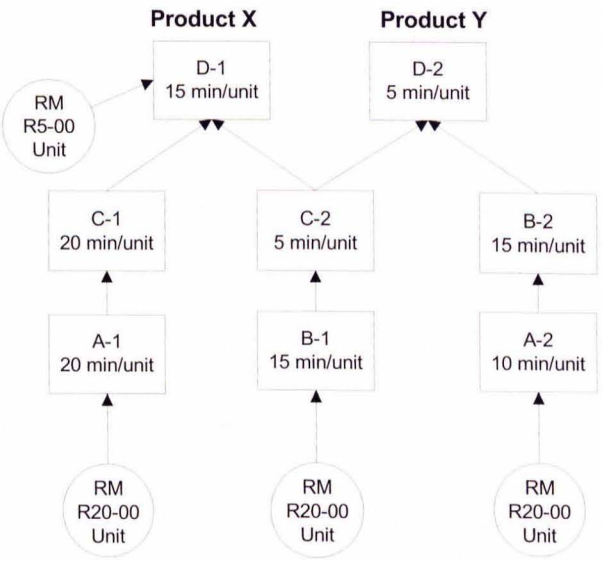

Fig. 1. The processing and supplier information [4]

C. Analysis – Activity based costing

From the data provided a summary can be made when the profitability of the two products are considered. Processing time is taken as the activity cost driver. This summary is shown in Table II.

The three decimal points used for product cost and product profit in this case make sense as we are dealing with perfect data. It does not make sense in the real world where processing times are based on averages. Yet, many activity-based cost proponents will still provide answers with a large number of decimal places, as if that would be an indication of accuracy. As the data are inaccurate, the decimal points are meaningless. From the analysis it is clear that Product Y is more profitable than Product X as it has a higher selling price, while at the same time consume less capacity and raw material costs.

Table II
Activity-based costing analysis

	Product X	Product Y
Selling price	R95.00/unit	R105.00/unit
Material (variable) cost	R45.00/unit	R40.00/unit
Contribution margin[a]	R50.00/unit	R65.00/unit
Capacity required	75 mins/unit	50 mins/unit
Product cost	R91.875/unit[b]	R71.25/unit[c]
Product profit[d]	R3.125/unit	R33.75/unit

[a]Contribution margin = Selling price minus variable cost

[b]Product cost for X was calculated as (Capacity required X Minute rate) plus variable cost i.e. (75 mins X R1500/2400 mins) + R45 = R91.875

[c]Product cost for Y was calculated as (Capacity required X Minute rate) plus variable cost i.e. (50 mins X R1500/2400 mins) + R40 = R71.25

[d]Product profit = Selling price – product cost

Given the preceding analysis, the company should try to optimize the sales of product Y in order to maximize profits. Given the fixed market demand, which seems to be a constraint, one will produce and sell the full complement of 60 of X and 60 of Y. This would lead to a profit of:

60(95–45)+60(105–40)–(4*1500) = R900 profit/week.

The problem however, is that operations cannot produce the full number of units as there is not sufficient capacity on resource B (See Table III for the capacity requirements analysis). Thus resource B is the real constraint of this company, not the market.

Table III
Capacity requirements analysis

Resource	Product X	Product Y	Total mins req'd/week	Mins/week available
A	60(20)	60(10)	1800	2400
B	60(15)	60(30)	**2700**	2400
C	60(25)	60(5)	1800	2400
D	60(15)	60(5)	1200	2400

Since resource B is the real constraint and product Y is more profitable than product X, one will first produce and sell the 60 units of product Y before producing and selling whatever quantities of X can be produced on the remaining time of resource B. Thus if 60 units of Y is produced on B, the time remaining for X would be:

2400 mins – 60(30) = 600 minutes of B

With 600 minutes of B available for X, the quantity of X that can be produced is:

600 mins/15 mins per product X = 40 units of X

Thus, considering B as the constraint and product Y to be more profitable than product X, the mix that would optimize profit for the company would be 40 units of X and 60 units of Y. This mix would lead to a profit of :

40(95–45)+60(105–40)–(4*1500) = -R100 profit/week.

These results would normally lead one to conclude that the organization is not profitable and that money should be spent in order to get more of B since B is the constraint.

D. Analysis - Throughput accounting

However, before any money is spent – which may not be necessary - another alternative should first be explored. What if some mistake was made in calculating the most profitable product, either the mathematics itself or the underlying assumptions driving the equations?

If one assumes that X is really more profitable than Y, counter-intuitive as it may seem, one will first produce 60 of X and what time is left on B will determine how many of Y can be made. Thus if 60 units of X is produced on B, the time remaining for Y would be:

2400 mins – 60(15) = 1500 minutes of B

With 1 500 minutes of B available for Y, the quantity of Y that can be produced is:

1 500 mins/30 mins per product Y = 50 units of Y

Thus, considering B as the constraint and product X to be more profitable than product Y, the mix that would optimize profit for the company would be 60 units of X and 50 units of Y. This mix would lead to a profit of :

60(95–45)+50(105–40)–(4*1500) = R250 profit/week.

E. Results discussion

These results lead to the conclusion that the calculations made in Table II are wrong and that looking at the organization as a whole, X ***is*** the more profitable product to be made. Goldratt [4] proposes to use the ratio of contribution margin to constraint time to calculate the profitability for each product. Thus for X we earn R50.00 for every 15 minutes spent on the constraint (R3.33 contribution per constraint minute), whereas for Y we earn R65.00 for every 30 minutes spent on the constraint (R2.16 contribution per constraint minute). Clearly X earns contribution at a higher rate than Y. This approach (called throughput accounting) considers the constraint and gives it the appropriate importance, whereas product costing does not consider the existence of the constraint, treating all resources as being equally important. However, there is nothing new in this approach. Cost and management accounting text books have included this technique at least since 1981 (see [6] and [7]), and Noreen [8] states that *"introductory management accounting textbooks routinely include material on the use of the contribution margin per unit of the scarce resource"*. The problem is the use of this technique remains in the textbook and classroom and does not feature in real life, where its superiority over product costing in short term decision making is clearly evident, as has been demonstrated in the preceding case. Profits

have improved from -R100 per week to R250 per week without the company having spent any money.

III. Throughput Accounting in Long-Term Decisions

A. Introduction

Fixed cost is not ignored in throughput accounting, as many critics believe. Fixed costs are ignored when it is not relevant to the decision being made, and included when it is relevant. This approach is in accordance with management accounting principles such as [7]:

- Sunk costs are not relevant costs; and
- Future costs that do not differ are not relevant cost.

Despite these principles being well known, in reality many mistakes are being made when decisions are made concerning long-term investments, as the following case will illustrate. Throughput accounting will then be applied to the same case to illustrate how the decision could have been improved.

B. Case data and costing analysis

The case data (see Table IV) come from a company in the industrial manufacturing sector and the company will remain anonymous.

Table IV
Order analysis

	Product 8080	Product 8108
Demand	750 000/year	300 000/year
Material (variable) cost	R15.30/unit	R26.81/unit
Fixed cost (allocated)[a]	R4.96/unit	R6.38/unit
Product cost[b]	R20.26/unit	R33.19/unit
Selling price[c]	R21.23/unit	R35.00/unit
Product profit[d]	R0.97/unit	R1.81/unit

[a]Fixed cost allocated included overheads and machine time but excluded labor, due to a labor constraint considered separately

[b]Product cost was calculated adding variable cost to fixed cost

[c]It was assumed that selling price cannot be below product cost as that would lead to making a loss

[d]Product profit = Selling price – product cost

This company, being of relatively small size, had the policy of having all functions involved when preparing offers to potential customers. After having analyzed the process and capacity requirements, the operations director declared that they would have an internal constraint if they were to take this order. The constraint would be in the form of additional operators required to work a third shift to be able to make the volumes of the two products required by the customer. The constraint could be broken by hiring twenty more operators at a cost of R4 000–00 per operator per month. However, they would have to hire them for at least a year, which meant that the increase in fixed cost would be R960 000 per year. The human resource director was willing to hire the required number of people provided the profit resulting from the order was more than R960 000.The financial director made the calculation that they would make a profit of:

$$NP=750000(21.23–20.26)+300000(35.00–33.19)– 960000$$
$$= R310\ 000$$

Thus a profit of R310 000 would be made on the order if they were awarded the order; which, for a company of their size would have been quite significant. On top of that, they would be creating employment opportunities and earn foreign exchange as the customer was from abroad.

The marketing director prepared the proposal for their customer, as from the company's perspective it seemed to be a profitable order to accept based on the above calculations. Furthermore, they did know where their constraint was and they also knew what the increase in fixed cost was going to be. To their surprise the potential customer (being price sensitive in a commodity market) requested them to cut their selling prices to at least R19.10 for the first product and R32.00 for the second product, and if possible, go lower than those two figures. By just comparing the proposed selling prices to their product cost, without even considering the increase in fixed cost immediately caused them to withdraw from the tendering process as the maximum price the customer was prepared to pay per product was below the product cost of that product.

C. Analysis – Throughput accounting

Even though this company knew where their constraint was and what the increase in fixed cost would be, they ignored the fact that the fixed cost allocated to this order was not relevant as it would still have to be paid (and borne by other products) if this order was not accepted i.e. the allocated fixed cost is a cost that will not differ in future regardless of whether the order is accepted or not.

A very simple throughput accounting calculation is needed to find the solution space for the selling prices of two products that will ensure profitability for the order and the company. One needs to know what the selling price of the one product needed to be if the other product is to be sold at variable cost only and still cover the increase in fixed cost. Then the two products are swapped around and the same calculation is made again. Breakeven for the first product (8080) is thus calculated as:

$$BE_x=750000(x - 15.30) + 300000(26.81 - 26.81)– 960000$$

When solving the equation x = 16.58. This means that if the first product is sold at R16.58 and the second product at its raw material cost, the organization would break even on this order although the fixed cost has increased by R960 000.

Breakeven for the second product (8108) is thus calculated as:

$$BE_y=750000(15.30 - 15.30) + 300000(y - 26.81)– 960000$$

When solving the equation y = 30.01. This means that if the second product were sold at R30.01 and the first product at its raw material cost, the organization would break even on this order although the fixed cost has increased by R960 000.

The solution space is the shaded area as indicated in Figure 2. The diagonal line represents the R960 000 increase in fixed cost. Analyzing the solution space will allow one to come to the conclusion that even when selling one of the two products below its variable cost, a profit can still be made on the whole order, provided the other product's selling price also falls within the solution space in such a way that it more than offsets the loss on the other product.

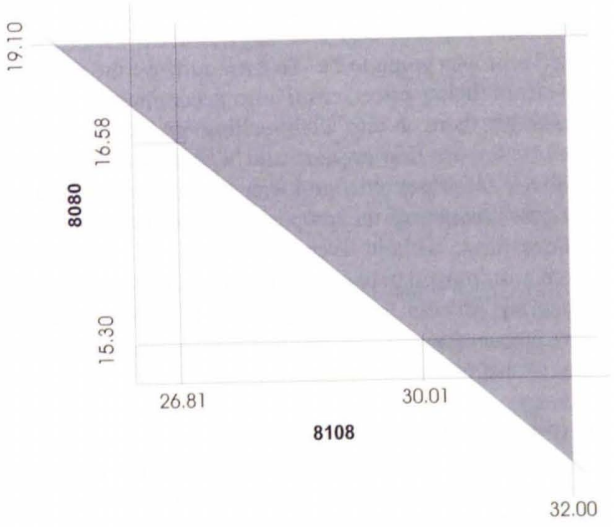

Fig. 2. Selling price solution area

Therefore, as long as selling prices for the two products are chosen below the maximum prices required by the customer *and* above the fixed cost line, the order will be profitable. If selling prices of R19.10 and R32.00 are chosen, the profit for the order will be 750 000(19.10–15.30) + 300 000(32.00–26.81) – 960 000 = R3 447 000! Compare this figure to the original profit calculation of R310 000 for this order based on product cost (even though the calculation resulting in R310 000 profit was done using higher selling prices than the throughput accounting analysis).

D. Results discussion

What is very obvious from the preceding analysis is that product cost is not only irrelevant; it is needed for neither short nor long-term decision-making. Many arguments are posed why product costs are necessary, the most important ones being:

- Product cost is necessary to determine selling price.
- Product cost is necessary to determine the minimum selling price at which a profit will still be made.
- Product cost is necessary to calculate breakeven.

In answer to the first argument, supply and demand is the most important determinant to establish selling price. If a product does not sell at a certain price, then the price will be dropped to stimulate the demand, without any changes in product cost and vice versa. The reason is that product cost is a function of fixed and variable cost only and not a direct function of selling price, therefore it is totally irrelevant in establishing selling price.

As for the second argument, a product makes a contribution to the bottom line of the organization as long as the selling price is more than the true variable cost. With true variable cost we mean cost that vary in direct proportion to the number produced, which excludes direct labor when paid on a per time basis. A product will thus always be profitable (making a contribution to the bottom line) as long as the selling price is more than the true variable cost. In a multiple product environment such as the one analyzed, it is even possible to be profitable on the full order when selling one product below its variable cost as has been indicated in the analysis. Product cost is not necessary for determining minimum selling price.

The third argument relates to product costs being necessary for calculating breakeven. In the preceding analysis breakeven for the individual products and the combination of products were calculated without the use of product cost. The basic equation to calculate breakeven is where net profit equals zero therefore where:

$$\text{Volume (Selling Price} - \text{Variable Cost)} - \text{Fixed Cost} = 0$$

When this equation is solved, the breakeven volume can be expressed as:

$$\text{Volume} = \text{Fixed Cost}/(\text{Selling Price} - \text{Variable Cost})$$

Product cost is nowhere to be seen in this equation. If a breakeven selling price is to be calculated for a certain volume, the equation is:

$$\text{Selling Price} = (\text{Fixed cost}/\text{Volume}) + \text{Variable Cost}$$

It can be argued that this last equation is the calculation of product cost. However, the intention was to calculate the selling price that will allow breakeven for a specific volume. As volume has been chosen arbitrarily, and volume sold being determined by many market factors (such as selling price itself, product quality, product variety, delivery speed and delivery reliability, lead times, variety and service), it implies a huge amount of uncertainty as far as the volume is concerned, therefore the same level of uncertainty will apply to the breakeven selling price or product cost if one chooses to see it that way. Since fixed and variable costs are known factors, the amount of uncertainty in this equation due to the uncertainty in volume, can be illustrated by the following:

Product Cost = (Fixed Cost/Volume) + Variable Cost

⇨ Product Cost = f(Volume)

⇨ Product Cost = f(f(Demand))[1]

⇨ Product Cost = f(f(f(Selling Price, Quality, Variety, Delivery Speed, Delivery Reliability, Service)))[2]

It can thus be concluded that in the absence of known demand (i.e. volume), that it is impossible to set up, obtain the data and solve the last equation, which implies it is impossible to calculate product cost as the basis for determining selling price.

In the case discussed this approach was used as the volumes were known and fixed. However, the intention was to calculate the breakeven selling price for the products to allow the solution space to be defined, not to determine an arbitrary product cost.

IV. Conclusions

Senge [9], when talking about systems, state that small changes produce big results, but the areas of leverage are many times not easy to see. In this particular case, the small change required is required within the way we think about product costs for short- and long-term decision-making. Being a small change does not indicate that it would be easy to make the change. It is much more difficult to make a change concerning ingrained paradigms or the way we see the world.

Within the cases presented, two important principles came to the fore. They are:

- The constraint should be considered and accounted for properly in all decision making
- The constraint primarily determines which fixed costs are relevant and which not to include in decision making, both short-term and long-term

Considering these principles leads to the conclusion that if you make decisions without considering and accounting for the system constraint properly, is like playing Russian roulette with one chamber empty. You have a very good chance of ending up in a bloody mess, and very dead.

As has been demonstrated, throughput accounting is not only a short-term optimization technique, but provides equally good results for making long-term investment decisions as well. Costing based on an allocation base, will always be contentious and lead to differences of opinion as to which cost allocation base should be used. Throughput accounting provides clarity of meaning to ensure the inclusion of only the relevant issues in decision making.

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[1] Volume = f(Demand)

[2] Demand = f(Selling Price, Quality, Variety, Delivery Speed, Delivery Reliability, Service)