Costing for Decision-Making in a Theory of Constraints Environment

Panayiotis Ifandoudas*
Bruce Gurd*

Abstract

Adherents to the Theory of Constraints (TOC) have made clear their antipathy to precise cost accounting. We argue that they have something in common with early writers who were concerned about the allocation of costs. However, given the lack of attention to the long-term in TOC we explore, using an action research approach over a four year period, the relevance of TOC for both long-term and short-run decisions. We argue that TOC does meet short-run decision relevance although it is not entirely adequate for longer term decisions.

Keywords

Costing
Decision-Making
Constraint Management
Linear Programming Models
Pricing
Theory of Constraints

Introduction

The criticisms made of costing and the allocation of overheads has continued for over a century. Despite its potential to overcome the problems of traditional absorption costing, few papers have appeared on the Theory of Constraints (TOC) in refereed accounting journals even though there has been a stream of papers in the practitioner literature (e.g. Corbett, 1999). This may suggest that the Theory of Constraints is perceived as purely of practitioner interest or lacking “theory”, being a “deductive theory” (Kaplan, 1998, p. 107). Yet TOC, as a decision tool, can provide a practical solution to the problems of absorption costing debated for over a century while integrating a method of constraint management superior to the linear programming models included in most management accounting textbooks over the last 40 years. The originator of TOC was Eli Goldratt, an American nuclear physicist. Although Goldratt has no link with the management accounting literature, his arguments, rather than being novel can be seen as a continuation of the contentions of writers in cost accounting fifty years ago. We demonstrate that TOC is short-term in nature although it can be used to form the basis of a long term strategic decision making process.

Since the publication of Relevance Lost (Johnson and Kaplan, 1987) the arguments against traditional absorption costing have been well laboured by both academics and practitioners (e.g. Cooper and Kaplan, 1988; Plenert, 1999). The activity-based costing writers argued that changes in the business environment, like substantial reductions in labour cost (Plenert, 1999), may invalidated absorption costing assumptions although the flaws may be in the use of absorption costing information designed for financial accounting purposes being used for decisions. However, absorption cost information still appears to be used for decisions such as make or buy, cost reduction and product mix (Brierley et al., 2001) using predominately a single cost driver and arbitrary allocation methods. This prevails even in sophisticated manufacturing systems (Durden et al., 1999).

*University of South Australia
A critique of conventional cost accounting is hardly novel. Our paper demonstrates the contribution of the Theory of Constraints as a possible solution to the continuing problem of the misleading information supplied by conventional cost accounting systems. The paper is arranged as follows. First, there is a literature review which provides a brief re-iteration of the perhaps forgotten classic literature followed by a re-iteration of TOC and the clashes as well as the complementarity of TOC with various forms of accounting. The second section explains why an action research design is an appropriate research design to investigate and approach like TOC. Third, there is a presentation of the research results of the action research case site which demonstrates that TOC does provide relevant decision-making information. The final section provides a conclusion from the research and a future research agenda.

Review of the Literature

The Classic Literature on Cost Data and the Theory of Constraints

On commenting on the evolution of costing, Solomons (1968) cited the industrial revolution as creating the factory system and as such raising the unresolved problem of how to adequately deal with the notion of overheads. Even as early as the turn of the 20th century many writers questioned the use of arbitrary allocations of overheads and argued that the time horizon is the most critical factor (Solomons, 1968). Goldratt would have found much in common with Hamilton’s (1910, p.31) comment, “What, for instance, is the use of splitting up a manager’s salary between departments? If a department be shut up, can a portion of the manager be dispensed with?” In the short and medium term the level of production will have no effect on a supervisor’s salary; and outsourcing products that have been allocated part of the supervisor’s salary as overhead will, likewise, have no effect on the amount paid to a supervisor.

Despite this objection being noted by Beer, in 1954, the practice of promoting products due to the misallocation of overheads appears to continue to happen with deleterious consequences (Smith, 2000). Furthermore, Beer (1954) argued that the greater the determination to allocate overheads to products, the greater will be the need to categorise costs in an arbitrary fashion that continues to conceal the heterogeneous operational situation. Beer (1954) was also one of the earliest to note that the use of standard costing provides no guidance as to how to improve operational efficiency but instead promotes the status quo.

Solomons (1968) noted some early critics of using allocated overheads for setting a selling price. Emerson (1904) argued that selling price was determined by the market. As long as each product makes some contribution to overheads and profit, it was neither possible nor necessary to say how much above and beyond prime cost each product should earn. Baxter and Oxenfeldt (1961) agreed, and went further by suggesting that the market price causes changes in the cost structure of the firm and not that cost dictates price. Using cost-plus pricing might give the impression of guaranteeing profit yet it might result in a price too high to sell enough products to cover costs. Thus, early writers identified the importance of all products generating throughput based on an externally set market price.

The use of excess capacity to contribute further throughput was also recognised by Baxter and Oxenfeldt (1961) who argued that using idle capacity to produce products should not attract the allocation of overheads since it raises no extra expense (save for deterioration of machines). Utilisation of capacity was recognised as important in the literature and there was a recognition that within a factory, resources varied in capacity. Utilisation of these various resources was therefore a strongly debated topic. Beer (1954) argued that the solution lay in operational research through game playing and linear programming. Indeed linear programming was used by Ijiri et al. in 1963 for the purpose of optimising production given constraints. Operational decisions could be made based on the firm’s constraints. Demski (1968) also gave a detailed example of linear programming in action and noted several key areas such as finite capacity, and constrained resources, but most significant was his identification of the value of the time products spent on the scarce resources “Concentrating on a physical measure of capacity, as is done
in traditional variance analysis procedures, is not sufficient because the same amount of physical capacity can be used to produce more than one product” (Demski, 1968, p539). The underlying principle to making traditional costing decisions using the TOC is calculating the throughput per unit of time spent on the constraint, a principle known to accountants for many years:

“The firm should produce the product that shows the greatest contribution per unit of limiting factor. It will produce as much of this product as it can sell. If resources are still available, it will turn next to the product showing the second highest contribution per unit” (Samuels, 1965, p. 542).

As is evident from the literature, TOC is not breaking new ground when it comes to making traditional cost-based decisions. It is using knowledge derived over fifty years ago within accounting research.

The Potential and Limitations of the Theory of Constraints

The concepts underlying TOC have been well expounded in the accounting research literature (Dugdale and Jones, 1998a, 1998b). TOC is at odds with traditional cost accounting in that it leads to non-constrained resources working below capacity, causing local efficiency ratios to suffer. TOC is based on the premise that global efficiency is of more benefit than local efficiencies. Maximising local optima, although raising efficiency rates, can lead to a reduction in profits (Corbett, 2000) as throughput, the rate at which the system generates money through sales (Rahman, 1998), is maximised. Traditional cost systems look to raise local efficiencies to lower the overhead absorbed by the products. This procedure can result in unrecognised holding costs for work in process inventory and higher write-offs for unsaleable stock.

TOC uses three basic measures to determine the operational activities of a business – throughput, inventory and operating expense – and to generate throughput as quickly and efficiently as possible. Three global measures go with these operational measures – net profit, return on investment and cash flow. To facilitate measuring the performance of the business, Dugdale and Jones (1998b) provided four measures suggested by Goldratt and also noted seven measures that Noreen et al. (1995) found currently in use.

TOC provides a theory of transformation that informs managers as to what, why and how to change existing practices (Dugdale and Jones, 1998a) resulting in a claimed reduction in lead-time, cycle time, and inventory while improving productivity and quality (Goldratt and Fox, 1987; Razaee and Elmore, 1997). Lead-time is reduced by only producing products to fulfil customer orders. The focus on quality is a result of stretching the bottleneck to its full capacity by not producing defective parts (Goldratt & Fox, 1993). One of Goldratt’s five steps was to ensure that inertia did not set in. Hence as constraints shift there should be continual re-evaluation of the product mix. Kee (2001) put forward the idea that the marketing department stay ahead of the production department to align sales efforts with a change in product mix due the elevation of the constraint. The marketing department should be informed of and respond to shifts in constraints.

A long list of TOC advocates offer scenarios to illustrate the effectiveness of the five step process to produce the most profitable product mix (Goldratt, 1990; Umble & Umble 1998; Smith 2000;and Atwater & Gagne, 1997). Blackstone (2001) argued that the marketing and sales departments must be aware of the throughput dollars per constraint and push those products in the market place and not the ones with the highest selling price or margins. This optimisation of production and marketing with respect to the constraint ensures the most profitable short-run product mix.

Other literature that supports the view that the TOC is superior for operational decisions is Cox et al.’s (1997) analysis of transfer pricing and the make-buy decision. When the external price is less than a cost-based transfer price, it may still be more profitable to purchase internally when using TOC to take account of the impact on the constraint. Sheu et al. (2003) presented a similar example, although focused on the optimality of TOC in the make or buy decision compared to the allocation of overheads. Sheu, et al. (2003) combined
Activity Based Costing\(^1\) (ABC) and the TOC to extend the time horizon of the decision to take into consideration the long-term effects.

Despite these benefits, TOC is criticised for its disregard for allocating overheads to products. Tollington (1998) refuted these criticisms and argued for the importance of a holistic management approach where the importance of maximising throughput and response rates outweighs the benefits derived in chasing the elusive dream of an accurate product overhead cost.

Two critics of TOC have been Kaplan and by implication, Shank. At the 1989 annual meeting of the American Accounting Association, Kaplan (1990, 1998) argued that the TOC treats erroneously almost all parameters such as prices, product mix, product design and labour rates as fixed. Furthermore, he argued that placing all costs into a single category of operating expenses created a bigger blob of unallocated costs than traditional costing. The argument is based on the assumption that the TOC makes all decisions based solely on the effect of throughput with a complete disregard to operating costs and inventory. However, decisions being made under TOC are based on analysing all three measures. A favourable decision will result in throughput increasing more than the combined change in inventory and operating expense, or in operating expense reducing without any decrease in throughput (Goldratt, 1990). The simple process of assessing the effects on operating expense and inventory demonstrates that TOC does not consider costs as fixed and unimportant when making decisions.

At the same conference Shank (1990) attacked the contribution margin approach, and by implication TOC, because it promotes products with the highest contribution margin regardless of the increase in fixed costs. However, we have argued above that in the case of TOC Shank’s claim is false, as both operating expense and inventory play an important part in decision making and encourage products with the highest throughput per constraint minute. Shank (1990) further contended that following a contribution approach will always lead to businesses never dropping products, continually adding products and always making instead of buying. This argument is unsustainable if constraints are recognised. If throughput is lost from an outsourced product the operating expenses place a greater burden on the remaining products (Smith, 2000). Under TOC, a product will be dropped if there is a capacity constraint and it can be replaced with a product with higher throughput per constraint. It is traditional absorption costing which after an incorrect buy rather than make decision causes the overhead to be spread over fewer products and can result in a spiral of always buying instead of making (Smith, 2000). Under TOC, the make instead of buy decision is contingent on the constraint and whether the increase in throughput is greater than the changes in inventory and operating expense (Goldratt and Fox, 1993).

Shank (1990) also puts forward the argument that the contribution approach encourages the strategy of lowering prices to gain market share. The benefits of a reduction in lead-time, cycle time, lower inventory and improvements on productivity and quality (Goldratt and Fox, 1987; Razae and Elmore, 1997) that have been reported under the TOC suggest that this approach does not lead to price-cutting. At best a premium price may be charged and at worst competitors’ prices matched, with the business left to compete on short lead times and quality.

A counter to the Shank argument is to move to Resource Consumption Accounting (RCA) which is like “marginal costing with characteristics of ABC” (Sharman, 2003, p.30). Building from German cost accounting (Grenplankostenrechnung), Gosselin (2007) suggests it is designed to capture the best of both European and American approaches to costing. White (2009) suggests that there are three key features of RCA – causality, responsiveness and work. It moves away from the concept of variable cost to proportional cost and handles both idle capacity and costs that support the product line that should not be absorbed (Sedgley and Jackiw, 2001; White, 2009). Yet while considered an advance on

\(^1\) Activity-based costing is defined in this paper as; “a costing method designed to provide managers with cost information for strategic and other decisions that potentially affect capacity and therefore “fixed” as well as variable costs” (Garrison, Noreen and Brewer, 2010, p.308).
ABC (IFAC, 2009) it still does not cost on the single constraint in the system as TOC does. It was not considered in this case because of the lack of standard operations at the resources level.

Although many criticisms of TOC are based on misconceptions, the criticism that the TOC is short-term in focus is justified. It is accepted that in the long run all costs are variable and it is argued by Fritzsch (1997) that TOC solutions are less effective as the time horizon grows due to its treatment of costs. Kaplan (1990) and Yahya-Zadeh (1999) argued that although the TOC can lead to short-run optimisation it is misleading for long-term decisions. In this context the merger of TOC and ABC appears useful (Bakke and Hellberg, 1991; Salafatinos, 1995; Sheu et al., 2003).

Based on this analysis of the literature, the research problem was to explore the practicality of implementing a system without arbitrary cost allocations and yet arriving at data that could be used for decision-making. The goal was to accept the challenge to operationalize the position of non-allocation. In particular, a range of issues needed to be explored in a longitudinal design:

1. Could TOC be used for both short-run and long-run decisions?
2. Can TOC data be successfully used across the business? Could managers’ in an organisation effectively abandon traditional cost information for decisions such as pricing?
3. In a real case, how does the decision-making approach adjust to the constraint continually shifting within a production environment and then to the market?

The next section introduces the case study site and the action research approach used.

**Case Study Approach**

In 2001, the CEO of AEM Australia approached several universities with the purpose of seeking a research project into the decision usefulness and strategic aspects of TOC. AEM was a producer of switches and transformers for electricity utilities across Australia. The company had been very successful in adopting TOC as an operational approach, and by 2002 this operational system was driving the business forward with reductions in lead times from 24 weeks to 6 weeks and a doubling of turnover the most dramatic effects. Yet AEM began to face issues in the areas of product pricing, middle to long term strategy, outsourcing, growth, inventory and marketing, which the TOC did not provide adequate guidance in the way that it solved the operational issues. A three-year research program was adopted in a university partnership to address these issues.

The research approach was action research that allowed for the construction and testing of theoretical solutions over a four and a half year time period, 2002 to 2006. Two action research projects co-existed in parallel - the solution to a practical problem and the writing up of an academic research reflection (McKay and Marshall, 2001). The first cycle is the problem solving cycle that focuses on the method to produce a solution to the problem. The second cycle is the research interest cycle that focuses on the generation of knowledge.

An early project was to develop a tool based on TOC that the company could use to aid in the setting of tender prices and to highlight product profitability. The process of costing a product involved using engineering drawings to provide a total material cost (including all costs with a one-to-one ratio) and total time on the constraint. On the other side, a product pricing model was developed that sets a minimum selling price (throughput/constraint hour = operating expense / constraint hour) and estimates the throughput at selling the product at various prices.

The system was needed to facilitate making decisions regarding product mix, make or buy, tender pricing, order pricing and long-term strategic decisions. The CEO needed to be able to manage by being able to make strategic decisions based on the manufacturing capabilities. The absence of any product cost data, as per pure TOC, created issues as to how to assess make or buy decisions and to determine which products were contributing most to throughput. The sales department needed to understand what the optimal product mix was and to market the products with the most throughput per constraint minute. The engineering department also required product profitability information to assist them in
making decisions on product development to maximise throughput.

Initially the environment of the manufacturer created problems because all products produced were custom made and therefore there was no standard raw material structure. The product mix consisted of custom-made products, mainly disconnection and earthing switches that involved approximately 300 parts and 5000–6000 manufacturing operations, involving in-house manufacturing and subcontracting. The cost of surface finishing was not captured by the system, thus the raw material cost of this step was estimated when calculating throughput.

The actual constraint presented its own problems. The internal constraint was machinist hours, because there was an inability to be able to acquire this skill, especially in a way that would be flexible with volume changes.

![Problem Solving Cycle](image1)

**Figure 1: Action Research Cycle**
(Adapted from McKay and Marshall, 2001)
However, due to the nature of the environment, the constraint shifted between the internal constraint and the market. Most constraints ran in real time. Internal constraints are not rigid as the pure models suggest. When the constraint shifted to the market, all the calculations of throughput based on internal constraints became redundant.

Another important factor in determining throughput is selling price, which was not easy to establish in this industry in either the short or the longer term as it was determined by a tender for a contract. Factors that affected winning tenders were competitors, the value the customers placed on quality, and less visible services such as market knowledge. Tenders were for an unknown quantity and for a time period of three to five years. The more precise research question then was: is it possible to give a selling price in the tender that will contribute sufficient throughput over the period of the contract and over the number of products that will be produced that is based on more than just a guess?

The major problem was that no effective management decisions regarding product mix could be made. Forecasting throughput, operating expenses and inventory was difficult. It was unknown whether the selling price of some products was covering the direct cost of manufacturing them and therefore contributing to throughput.

**Research Results**

AEM was one of the smallest companies to use the software tool, ST-Point, to manage the TOC process and calculate a production schedule. The successful implementation of the TOC throughout the business was partly attributed to the production schedule becoming the master planning document. Adherence to the schedule led to most areas adhering to the principles of TOC - constraint management and drum-buffer-rope. Purchasing followed the production schedule and could bulk to attain the best purchasing price and then arrange delivery to minimise inventory. By adhering to the purchasing list, the purchasing department as well as the stores receiving area began adopting and using TOC principles without the need for extensive training.

Following the coordination of materials was the production function. Batching to save set up times, always keeping machines and people active and focusing on reducing factory overhead are some of the most difficult hurdles to overcome when implementing drum-buffer-rope. Through the use of the production list and the management of material release, drum-buffer-rope was introduced into the workforce. The production list provided a sequence of manufacturing events that if followed ensured that the use on the constraint was maximised and that work-in-process was reduced. It was the adoption of the production schedule as the master planning document that facilitated the acceptance of the TOC throughout the organisation. The next step involved the adoption of the TOC principles for marketing, design and engineering functions.

**Marketing**

The production schedule provided a change process to TOC but not in marketing, design and engineering departments. Thus, a conscious choice from staff was required to abandon decision criterion such as overheads, profit margins, time, and capacity as defined within the management accounting paradigm, and adopt throughput measures such as throughput per constraint hour, operating expense, inventory, and constraint capacity. The most critical pricing decision was for long-term tenders because they comprised 79% of sales (2006 data). The length of the tenders also has implications for long-term financial performance. Short-term pricing decisions related to specific orders with quoted prices valid for a short period, usually three months. What was not clear in the tender process faced by AEM was the quantity or the product mix. The setting of a selling price needed to be competitive enough to win the contract and high enough to contribute to profit (throughput minus operating expense). The setting of prices was influenced by market knowledge, knowledge of competitors, material costs, manufacturing time, and gut instinct. The process of setting prices for orders which were outside the tender process used similar factors. As such the prices set in the tender affect the profitability of all the products sold. The collection of material costs and constraint time data were obtained via the OPT software ST-Point. Subcontracting costs

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were not captured by the system and were estimated by applying a flat rate to material costs, an error-prone process particularly with the large switches for which the subcontracting cost was well above the flat rate.

The positioning of the internal constraint presents a unique example from the hypothetical examples found in the literature (Goldratt, 1990; Umble & Umble 1998) which are machine or workstation constraints. They provide an ideal setting for implementing drum-buffer-rope and managing according to the constraint because the machine or workstation represents a fixed amount of operating time with little variability. At AEM, the internal constraint was skilled machinist time, which added to the complexity of the manufacturing flow and of costing. The processing time of a machine is relatively stable, as opposed to machinists who vary in skills and efficiency. Furthermore, the variability of the constraint increases when the constraint is people, as issues such as absenteeism, annual leave, sick leave and motivation are variables that affect the available constraint time.

Prior to the adoption of throughput measurements, the costing process relied on relatively accurate direct material cost. Labour hours were available from a software database; however, a consistent distinction between skilled labour (constraint time) and unskilled labour was not made. An arbitrary rate was applied for subcontracting costs such as galvanising, plating and machining. A labour rate was applied to determine product cost. A single plant wide overhead rate was used with allocation of overhead on a per labour hour basis. This product cost was then compared to what the managing director and the sales manager, through years of industry experience, determined was the market price. The final selling price was determined through the merging of the perceived market price and the product cost as well as assumed competitor behaviour.

The research involved refining the collection of product data to include subcontracting costs, defining skilled labour, assessing capacity, operating expense, and inventory. Once this process was complete, accurate throughput information was used to influence the setting of tender prices. An Excel spreadsheet (tender template) was developed to assess tenders in terms of throughput per product, total throughput, constraint usage, and average throughput per constraint hour. Consistent with the TOC literature on product mix, determining the throughput per constraint hour is the most accurate way to rank products and determine their contribution to the bottom line. Table 1 represents an excerpt from the tender template based on throughput pricing compared to a traditional absorption costing exercise.

Comparing the previous price to either of the throughput prices it is evident that the disconnectors (DB) were underpriced and the earthing switches (SE) were overpriced. Throughput pricing is determined using a target Throughput per constraint hour figure (in this example ($150 & $120), and is calculated by material cost + Target Throughput * Constraint Hours. The standard costing prices and the throughput prices appear to be similar because the constraint was skilled labour and a large proportion of the labour hours was skilled. If the constraint was a machine or a process vastly different from labour (or traditional cost drivers), then a greater discrepancy between absorption costing and throughput pricing would exist. Nevertheless, the use of throughput analysis was superior to the previous method for providing guidance on tender prices. Issues such as market price, previous price, competitor behaviour, and industry knowledge continue to play a major role in the setting of prices. The use of throughput analysis enabled the managing director and sales manager to accurately assess what affect various selling prices would have on the constraint and in turn the bottom line.

The managing director was responsible for the introduction and implementation of the TOC and continued to be responsible for the generation of production schedules. As a result, the managing director did not need any convincing of the beneficial aspects of the throughput approach nor its superiority in determining selling price. However, the determination of short-term pricing occurred within the sales department and a cultural shift in the setting of prices was needed.

Short-term pricing involved the quoting of prices outside the tender process. Previously,
price was determined on the basis of standard costing analysis. There were two issues with using standard costing: first, capacity was not taken into consideration, and second, overpricing and underpricing of products resulted in genuinely profitable orders being lost and unprofitable orders being won. The principle – and superiority – of a throughput approach was easily conveyed; the difficulty lay for the sales department was to accurately generate throughput per constraint hour information.

The first step in using this form was to determine total unit cost and hours on the constraint. The form generates three prices as a guide: an attractive selling price, competitive selling price, and lowest net selling price. These prices were based on throughput per hour and adjusted periodically as the lowest net selling price was set at the breakeven point (OE per constraint hour = T per constraint hour). Depending on the strategic importance of the quote, capacity and competitor issues, low competitive pricing or high margin pricing could be submitted. The decision could be reversed with the estimated selling price being entered and computing the effect on throughput percentage and throughput per constraint hour. Depending on whether the constraint is internal or external and the strategic importance of the order, an aggressive or high selling price could be offered. This is more consistent with TOC principles to be responding to the market price.

The pricing form was implemented in mid 2006 during a period when the constraint was external (demand less than supply) and the impetus was on the sales department to bring in sales outside the tender process. The use of the form enabled aggressive pricing on orders. The percentage of quotes won as measured in the monthly scorecard rose from 14% to 98% in the space of three months.

The throughput approach was successfully adopted by the staff in the marketing department for both short- and long-run decisions.

Table 1: Pricing under TOC Compared to Standard Costs

<table>
<thead>
<tr>
<th>Product</th>
<th>36kv DB</th>
<th>36kv SE</th>
<th>75kv DB</th>
<th>75kv SE</th>
<th>145kv DB</th>
<th>145kv SE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Standard Costing</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Material</td>
<td>$4,835</td>
<td>$1,745</td>
<td>$6,643</td>
<td>$2,115</td>
<td>$11,326</td>
<td>$3,381</td>
</tr>
<tr>
<td>Labour Hours</td>
<td>47</td>
<td>44</td>
<td>45</td>
<td>51</td>
<td>49</td>
<td>57</td>
</tr>
<tr>
<td>Direct labour hours (@ $35/hour)</td>
<td>$1,645</td>
<td>$1,540</td>
<td>$1,575</td>
<td>$1,785</td>
<td>$1,715</td>
<td>$1,995</td>
</tr>
<tr>
<td>Overhead (@ $11/direct labour hour)</td>
<td>$4,700</td>
<td>$4,400</td>
<td>$4,500</td>
<td>$5,100</td>
<td>$4,900</td>
<td>$5,700</td>
</tr>
<tr>
<td>Plus 10% Profit margin</td>
<td>$1,118</td>
<td>$768</td>
<td>$1,272</td>
<td>$900</td>
<td>$1,794</td>
<td>$1,108</td>
</tr>
<tr>
<td>Standard costing selling price</td>
<td>$12,298</td>
<td>$8,453</td>
<td>$13,990</td>
<td>$9,900</td>
<td>$19,735</td>
<td>$12,184</td>
</tr>
<tr>
<td>Throughput Pricing</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Material costs</td>
<td>$4,835</td>
<td>$1,745</td>
<td>$6,643</td>
<td>$2,115</td>
<td>$11,326</td>
<td>$3,381</td>
</tr>
<tr>
<td>Constraint Time</td>
<td>41</td>
<td>36</td>
<td>36</td>
<td>36</td>
<td>39</td>
<td>44</td>
</tr>
<tr>
<td>Throughput 1 @ $120</td>
<td>$9,755</td>
<td>$6,065</td>
<td>$10,963</td>
<td>$6,435</td>
<td>$16,006</td>
<td>$8,661</td>
</tr>
<tr>
<td>Throughput 2 @ $150</td>
<td>$10,985</td>
<td>$7,145</td>
<td>$12,043</td>
<td>$7,515</td>
<td>$17,176</td>
<td>$9,981</td>
</tr>
<tr>
<td>Selling Price 1 (10% Profit margin)</td>
<td>$10,731</td>
<td>$6,672</td>
<td>$12,059</td>
<td>$7,079</td>
<td>$17,607</td>
<td>$9,527</td>
</tr>
<tr>
<td>Selling Price 2 (10% Profit margin)</td>
<td>$12,084</td>
<td>$7,860</td>
<td>$13,247</td>
<td>$8,267</td>
<td>$18,894</td>
<td>$10,979</td>
</tr>
</tbody>
</table>
Design and Engineering

There was a 76% increase in sales between 2004 and 2006 and market analysis indicated that the growth would continue. By the end of the 2005 financial year AEM was at capacity, which was reflected in the decline in delivery performance, and a strategy to increase total output was needed. The production capabilities of AEM were in synchronising production and being able to coordinate thousands of unique operations over a given schedule. The factory had no automation and did not have the economies of scale to mass produce like components. There were also operational health and safety issues involved in the handling of heavy components. By the middle of 2005, the constraint was situated internally as market demand was greater than capacity; the expected future demand would not be able to be met with existing resources. There were two options open at the time that would increase the constraint: employ more constrained resource and/or outsource constraint capacity. The employment option was limited as the Australian labour market was suffering from a skill shortage; therefore the capacity needed to come through outsourcing.

The plan was to determine firstly whether TOC principles could be applied to a make-to-order business that has an infinite number of possible product mixes, all driven externally by customer orders. The next step was to use these findings to create an outsourcing methodology and to then implement this policy to guide outsourcing decisions. If the decision was made to buy instead of make were there any cost savings? Unless employees are laid off the labour cost remains the same. The overhead that was previously allocated to that product does not disappear but is reallocated among the rest of the products, making them now more costly to make. In practice, labour costs and variable overheads remain the same (unless employees are retrenched or paid on a piece basis); the only financial effect is that instead of purchasing raw materials and manufacturing them to a certain level, this component is purchased at that level. Usually a manufactured component costs more than the raw materials it is comprised of. Thus the initial consequence of buying instead of making is a reduction in throughput which translates into a reduction in profit. However, the reduction in time on the constraint of that particular product may have a beneficial medium to long-term effect on throughput if the time per constraint hour increases and the number of products made is substantial enough to realise these savings.

From the outsourcing analysis, it was decided to standardise components and assemblies and then eliminate labour-intensive, inefficient or potentially hazardous operations and procedures within AEM. The latter involved the identification of components or assemblies with poor labour efficiency due to inadequate tools, equipment or space for manufacture or handling. Three specific products were identified to study in a project.

The improvement process was targeted at the tender contracts, which represented 79% of sales and because there is standardisation within each contract, as opposed to the custom-made products where this would prove a lengthy and difficult task. All products within the tender were broken up into voltage groups with throughput and constraint data provided on a per/part and total basis as set out in Tables 2 and 3.

Column 1 of Table 2 shows the parts list of the product group. This was broken into parts, with the named parts forming the focus of the improvement process. There were also extras that constituted the unique parts of each product and which were seen as too difficult to harmonise at that stage. Within this list each part was hidden for ease of use and once opened revealed the description, part number, material and subcontracting costs and constraint usage. All tender products within that group are situated to the right of the throughput data and asterisks were placed next to the parts that were within that product. The planning behind this spreadsheet was to list the various parts that each product used and to provide a guide as to whether the improvement process was practical.

Table 3 represents the bottom section of the spreadsheet where changes made to each part could be analysed. As engineering time was limited, a system was needed to ensure that any time spent on redesigning would result in a new part or process with considerable time savings. As noted, outsourcing a part often
results in an increase in material costs (decline in throughput) but a saving of time. An indication of whether the saving of time outweighed the increase in cost is the effect of time per constraint hour, which is the throughput generated per hour of time spent on the constraint. Thus, checks were put in place in the bottom two rows of the spreadsheet, as set out in Table 3, to highlight changes that resulted in a decrease of throughput per constraint hour. A check was also put in place to ensure that throughput as a percentage of sales did not drop below a certain point. The plan was to encourage the use of this spreadsheet to guide the engineering department during the conceptual stage.

### Table 2: Product Tables Containing Material and Subcontracting Costs and Constraint Usage on a Per Part Basis

<table>
<thead>
<tr>
<th>Description</th>
<th>Parts</th>
<th>Qty</th>
<th>Material</th>
<th>Sub-con</th>
<th>Time</th>
<th>Prod A</th>
<th>Prod B</th>
<th>Prod C</th>
</tr>
</thead>
<tbody>
<tr>
<td>Base Channel</td>
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<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bearing Assembly</td>
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<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>C/Blade Assembly</td>
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<td></td>
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<td></td>
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<td></td>
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<tr>
<td>D Shaft</td>
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<tr>
<td>Drive Plate Kit</td>
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<tr>
<td>Drive Plate Table</td>
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<tr>
<td>Flicker Kit</td>
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<td>Insulator Jacking Plates</td>
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<tr>
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<td></td>
<td></td>
</tr>
<tr>
<td>O/C Assembly</td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Op Handle</td>
<td></td>
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<td></td>
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<tr>
<td>Op Handle A0884-11</td>
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<td></td>
<td>$91.5</td>
<td>$1.3</td>
<td>2.55</td>
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<td>Op Handle A2-084-0884-P4</td>
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<td>$70.5</td>
<td>$6.2</td>
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<td>$70.5</td>
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<td>Open Stop Kit</td>
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<tr>
<td>Term Palm Assy</td>
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<td></td>
</tr>
<tr>
<td>Extra Parts</td>
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<td></td>
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<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Table 3: The Summary Section of the Spreadsheet Showing Each Product’s Throughput Analysis

<table>
<thead>
<tr>
<th></th>
<th>Product A</th>
<th>Product B</th>
<th>Product C</th>
</tr>
</thead>
<tbody>
<tr>
<td>Selling Price</td>
<td>$7,569</td>
<td>$8,450</td>
<td>$12,668</td>
</tr>
<tr>
<td>Original Cost</td>
<td>$3,124</td>
<td>$3,287</td>
<td>$6,346</td>
</tr>
<tr>
<td>Original Time</td>
<td>44.2</td>
<td>44.3</td>
<td>45.2</td>
</tr>
<tr>
<td>Original Throughput</td>
<td>$4,445</td>
<td>$5,163</td>
<td>$6,322</td>
</tr>
<tr>
<td>Original T/C hour</td>
<td>$101</td>
<td>$117</td>
<td>$140</td>
</tr>
<tr>
<td>T as % of Sales</td>
<td>58.7%</td>
<td>61.1%</td>
<td>49.9%</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>Product A</th>
<th>Product B</th>
<th>Product C</th>
</tr>
</thead>
<tbody>
<tr>
<td>New Cost</td>
<td>$3,197</td>
<td>$3,360</td>
<td>$6,403</td>
</tr>
<tr>
<td>New Time</td>
<td>42.2</td>
<td>42.8</td>
<td>43.6</td>
</tr>
<tr>
<td>New Throughput</td>
<td>$4,373</td>
<td>$5,090</td>
<td>$6,265</td>
</tr>
<tr>
<td>New T/C hour</td>
<td>$104</td>
<td>$119</td>
<td>$144</td>
</tr>
<tr>
<td>T as % of Sales</td>
<td>57.8%</td>
<td>60.2%</td>
<td>49.5%</td>
</tr>
<tr>
<td>T/C Hour</td>
<td>ok</td>
<td>ok</td>
<td>ok</td>
</tr>
<tr>
<td>T%</td>
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<td>ok</td>
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</tbody>
</table>
The problem addressed was how to meet the increasing customer demand given that internal capacity was full. The proposed solution was to implement a strategic outsourcing policy that raised total output and maintained profitability. The changes resulting from the modification of the operating handles and the overcentres reduced the constraint time on 75kv and 145kv disconnectors by approximately five hours at an increased cost of $150. This translates to a cost of $30 for every hour saved at the constraint. The relationship discovered was that if \( x \) dollars were spent on saving one hour on the constraint for a product whose throughput per constraint hour was greater than \( x \), then the profitability of that product increased, even though the total throughput of that product decreased. All 75kv and 145kv disconnectors had a throughput per constraint hour greater than $30 per hour and thus the contribution that each product made for the time spent on the constraint was increased. Prior to the changes being implemented AEM was able to produce 50 switches per month; thus saving 5 hours of constraint time per switch (by strategic outsourcing) translated to 250 hours of extra capacity for the month, for a total cost of $7500. The additional 20 switches that could be produced given the time saved would cover the extra cost and have a significant effect on increasing the bottom line. In effect these changes had the potential to increase capacity by 40%.

By the end of 2006 the process of strategic outsourcing and continuous improvement resulted in the following financial effects. Sales increased from $7.9m in 2005 to $12.5m in 2006 an increase of 60%. This increase was obtained with a minimal change in constraint capacity, which had a 1% rise from 33 700 to 33 900 hours. Operating expense remained stable (6% increase). As was predicted throughput percentage decreased by 4%, with throughput per constraint hour increasing by 42%.

**Growth**

Since the implementation of a management system based on TOC, AEM has maintained an accelerated growth rate (figure 4). This has been achieved in the absence of traditional costing and, more surprisingly, long-term costing. AEM has also faced challenges common to SMEs that experience rapid growth stages, including resource shortages in areas such as managerial experience, cash flow, technology selection and adoption; and physical capacity constraints. These challenges have been addressed with TOC forming the lion’s share of both the operational and strategic decision making.

![Figure 4: Growths in Sales, Throughput, Owners’ Equity, and Profit, 2003–06](image-url)
Resource shortages were addressed in the same way that bottlenecks in the production process were solved. The TOC five step process was applied in iterative cycles until the constraint was shifted to production or the market. Bottlenecks in the design, purchasing, and sales departments were addressed by refining processes and/or increasing capacity.

Conclusion

The Theory of Constraints provides challenges for both professional and academic accountants. Goldratt’s continual criticism of the “cost world” and of accounting may go unnoticed by itself but credible academic researchers such as Noreen et al. (1995) and Dugdale and Jones (1998) have brought it into the domain of academic management accounting. The Theory of Constraints provides a challenge to mainstream cost accounting which suggests that cost is the basis of much short-run decision-making. While recognising the problems of TOC, it is possible to develop approaches to making tactical and strategic decisions which build on TOC. This paper contains preliminary suggestions of how even pricing decisions in what might be viewed as a cost-plus environment could be resolved without the use of traditional costing. ABC or RCA may still be able to play a large part in long-term decision making. Many of the resource constraints identified in the growth stage could have been predicted through activity mapping given higher levels of production. The difficulty of applying ABC and TOC in this way is the availability of accounting resources; a problem that might be even greater with RCA. SMEs may not have the accounting resources available to produce financial accounts consistent with reporting requirements, TOC accounts for decision making purposes, and ABC information. In AEM’s case applying ABC to the 30–40 000 manufacturing operations per month would not have been feasible. Nevertheless, setting aside the practical difficulties of ABC and TOC implementation, the dual use of TOC and ABC for long-term decision making is still an important area for future research.

This paper suggests that academic and practitioner management accountants should not be too dismissive of developments in rival literatures. More complex costing systems may have been the trend with developments such as activity-based costing. Yet literatures such as human information processing would suggest that simple heuristics may be better than more complex decision models. Decision making rules based on throughput per constraint minute may outperform models based on more complex decision information. The information economics viewpoint may suggest that optimal decisions may be made with what is apparently sub-optimal decision-making. Importantly the paper suggest that managing holistically may mean that many accounting measurements that focus on local optimisation are at best misleading and at worst quite dangerous for the future of the firm.

Producing change to an entirely new perspective of decision-making will take time. As more evidence is produced of the possibilities of managing without conventional cost accounting data and variance analysis, practitioners and academics may be interested in experimenting with these “novel” approaches. Much more work needs to be done in this specific research endeavour in which the authors are engaged to produce more evidence of the possibilities. Implementation of these approaches with demonstration of improved performance will be necessary to provide conviction to change the current approaches.

References


International Federation of Accountants (2009), Evaluating and Improving Costing in Organizations, IFAC, New York.


