

Design for profiting – managing from different time frame perspectives

Pedro Araujo Parreiras (Mestrando do Prog. Eng. Produção, COPPE/UFRJ) paparreiras@yahoo.com.br
Ricardo Manfredi Naveiro (Professor da Escola Politécnica e COPPE/UFRJ) ricardo@pep.ufrj.br

Abstract

There are a number of articles or books' chapters relating theory of constraints (TOC) and activity based cost management (ABC/M) – most of them putting one against the other and some saying that they are complementary. But literature bringing these relations to the design process and creating a design for profiting environment is not well available and that is what this paper is about.

What are the objectives of a company's investors? The answers that come up to most respondents are probably raise profiting or increasing the return on investment. And how would that be related to design? It depends; the design process can help a company raise it's profitability either by designing products that will make the company better utilizes it's given capacity or by designing profitable products that will require a not yet available capacity.

On the first case, the functions of marketing, finance, design and manufacturing have to together find out what can be designed, produced and sold using the given resources and activities that are not constraining the system. The second situation occurs when these functions verify that the design of a new profitable product won't fit profitably the company's present capacity and thus a new capacity must also be designed and provided.

Key words: Activity based cost management (ABC/M), Theory of constraints (TOC), and Target costing.

1. Introduction

The economic success of manufacturing firms depends on their ability to identify the needs of customers and to quickly create products that meet these needs and can be produced at a low cost (ULRICH & EPPINGER, 1995). Target costing can sure help meet these requirements for economic success. Ulrich and Eppinger (1995) also stated that from the perspective of the investors of a for-profit enterprise, successful product development results in products that can be produced and sold profitably. This paper tries to bring a cost and capacity analysis to the interdisciplinary process of design by blending the methodologies of activity based cost management (ABC/M), capacity management, the theory of constraints (TOC) and target costing.

According to Noreen, Smith and Mackey (1995), the core idea in the theory of constraints is that every real system such as a profit-making enterprise must have at least one constraint. It is not wrong to say that the TOC has become a classic approach to make short term decisions, helping managers decide what the best or good mix to be produced next week or month is. Constraints need to be managed with special attention and may vary according to the product mix, market demands, work shifts and equipment investment. Why not drive the design process also to the production of products that will use today's non bottleneck capacity, optimizing the company's throughput?

On the other hand, McNair & Vangermeersch (1998) state that ABC (activity based costing) helps managers predict the impact of changes in volume and mix, process changes and improvement, introduction of new technology and product and design changes on activity cost. An ABC/M information system could help managers find what profitable products to design and what capacity is needed to make its production and sales profitable.

The fact that the market is shortening product life cycle year after year has become a common sense to everybody related to the design process in a for profit organization. But, if someone does not work on the design process, watching or reading media advertising is enough to know that some products models live less than a year – such as cell phones, laptops etc. This is one of the reasons the time required for a product enter the market also shortened. There are not much room or time for mistaking in this environment and many aspects have to be considered in the decision making process of the design phase.

As stated before, the goal of a company's investors are the return on investment and increase profiting. For that, the cash flow of a company life cycle has to generate an acceptable internal rate of return in different time frames: some investors may require a rapid return; others may be more patient and have long term perspectives. But, for a company with a design department and a mix of different products and clients, the products are designed, produced, launched, sold and discontinued and the enterprise's life goes on – as long as it's products mix generate that required return. The focus has to be on the product and client mix and how it will impact the company bottom line along the life of each product.

Target costing methodology helps achieve that goal by being market driven and considering the products life cycle. The target allowable cost of a product is determined by ideal selling price and expected profit margins (COKINS, 2002). According to Cooper (2002), at the heart of target costing lies a deceptively simple equation: **Target Selling Price – Target Profit Margin = Target Cost**. Activity based cost management and theory of constraints can help the decision of designing new products that will be produced in a new capacity configuration or better using today's capacity, respectively.

2. Activity based management and activity based costing

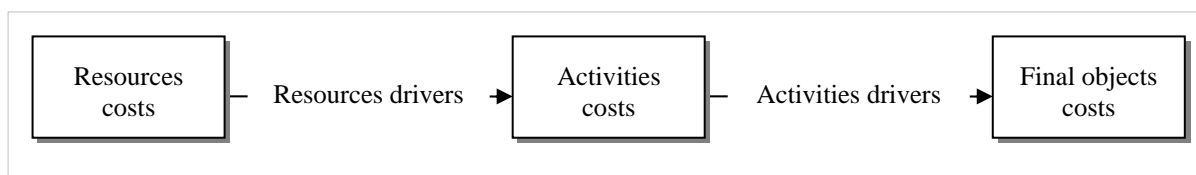
Activity based management is planning, improving and controlling of an organization in order to satisfy clients and other external needs and requirements (PRYOR, 2000). It is a management process that considers construction of value for clients and profits for stock owners as the main goal of a business. To score and achieve this goal, clients' demands must correspond to rationally utilizing the resources.

To satisfy these demands, the organization must have the knowledge of the clients' needs and preferences, the market competitors' characteristics and assume a compatible competitive position. The clear definition of the value packs offered to the market allows the value chain configuration, witch means that business, support and management processes must be aligned with what the clients want. This alignment is essential to secure the organization efficacy, meaning that the right things are being done (NETTO & PARREIRAS, 2004).

In another way, processes and activities execution needs an infra-structure composed of a variety of human, technological, materials and financial resources. The consumption of these resources is translated in cost to the organization, so must be done rationally. This is the efficiency dimension and intends to evaluate if the things are done in the right way (NETTO & PARREIRAS, 2004).

Activity based costing (ABC) is the methodology used to measure the cost of resources, activities and final objects costs. For that, it traces costs from resources to activities and from activities to final objects through cost drivers (resource and activity drivers, defined at table

2.1), as shown in exhibit 2.1 next. This theory considers mainly long term planning horizon and thus all costs may vary. Fixed costs – as in TOC – are the ones required for today's given capacity – as said before, in the long run all costs are variable.



Source: Adapted from COKINS, Gary (1996).

Exhibit 2.1 – ABC information flow

Table 2.1 below summarizes ABC terms. Some of them are used throughout next sections and it is worth to come back to this table if any doubt comes up along the paper reading.

Terms	Definition	Examples
Resource	Resources represent costs to the company and are utilized by activities or final cost objects.	Personnel, space, energy, equipment, materials etc.
Resource driver	A measure that rationally traces costs from resources to activities. The resource cost is driven to activities through the formula: resource driver quantity consumed by activity x (resource cost / total resource driver quantity).	Head count, area, percentage of time etc.
Activity	One activity is a series of tasks that need to be done to add value to the company's final cost objects. Some activities may not add value. Information on how much an activity costs and whether it adds value or not can help operational investments decisions on activity improvement.	Process order, machine, assemble, inspect, transport etc.
Activity driver	As the resource driver, it is a measure that rationally traces costs from activities to final cost objects. The activity cost is driven to final cost objects through the formula: activity driver quantity consumed by final cost object x (activity cost / total activity driver quantity). As shown in the next section, this article considers the total activity driver quantity available is the activity capacity.	Number of orders, machine hours, assembly hours, inspection hours, volume etc.
Final cost object	The final cost object is what is strategically interesting for the company to know how much cost. This information can help decision makers find out what final cost objects are profitable and the ones that are not. The ABC/M system also informs where the profitability (or the lack of it) come from and if it worth trying to make a non profitable final cost object into a profitable one.	Products, clients, sales channels, the company (business sustaining costs) and unused capacity.
Business sustaining costs	All costs from resources and activities that cannot be rationally traced to other final cost objects go to the company account. These are the business sustaining costs.	Advertising for the company image, strategy activities etc.

Table 2.1 – ABC terms definitions

3. Theory of constraints, throughput accounting and capacity management

According to Noreen, Smith and Mackey (1995), the theory of constraints uses what Goldratt named the throughput accounting system. This system has three building blocks: throughput, operating expenses and assets. These authors also define throughput as revenue less totally variable costs and operating expenses as all expenses that are not deducted in arriving at throughput. As Goldratt (1991) stated, at this theory, the system constraint must limit what the company strives for – the throughput.

As is said before, on Table 2.1 (ABC terms definitions), the total activity driver quantity available is the activity capacity. This article considers the ABC theory and thus resources availability will constraint activities' capacity and its driver's availability. What is said here can be better understood with an example: a machine activity consumes mainly five resources

– space, equipment, personnel, tools and energy. These resources are available differently from each other: the space and equipment are there 24 hours per day, seven days per week, personnel on contracted hours and the last two whenever necessary.

So, in this example, the first restriction of the activity is the personnel – until the work shifts do not fill up all machine time available, more people can be contracted to do it. There are sure other issues related to this increase of capacity: is there an overall infrastructure that support extra work shifts? Another option would make investments buying more machines, only if there is idle space to locate them at. If not, a new plant would have to be designed.

Capacity management has to consider different time frames perspectives. To increase or decrease the capacity available for an activity, it is necessary to allocate or reallocate people, buy or sell machinery, design and built a new plant or discontinue a existent plant etc. Somehow, a company's activities capacity to make and sell products – no matter whether they are products or services – has to be adjusted to the demand for it, today or in the future. If there is more capacity than necessary, an unused capacity cost will charge the company differently than its competitors. On the other hand, having less capacity than demanded will open a door for the competitors win the company's market share and may decrease the level of service expected by the clients.

According to the definitions and example above, every time the final cost objects demand more quantity of an activity driver's than it is available, this activity may be constraining the system from making more money than the market allows it to make. The bottleneck would than be the activity that first constraints the system at its optimal product mix – the one that would generate the greatest profit. Opposing to that, an interesting example is illustrated by Baxendale and Raju (2004), where all internal activities have unused capacity and the constraint is the marketplace and an optimal product mix does not need to be found – it is the market demand. In this case, market, design and strategic actions would be required to fill up that unused capacity trying to reach an optimal mix.

4. Target costing

Cokins (2002) stated that target costing is a technique that predetermines an ideal product cost to maximize profits across that product lifecycle and a nickname for it is "profit by design". Opposed to the traditional design process, as shown by Ulrich & Eppinger (1995) – when an economic analysis is done after refining specifications – on target costing the maximum allowable cost is an input to the design process. As exhibit 4.1 below show, comparing to conventional costing, costs switch from output to input of the process.

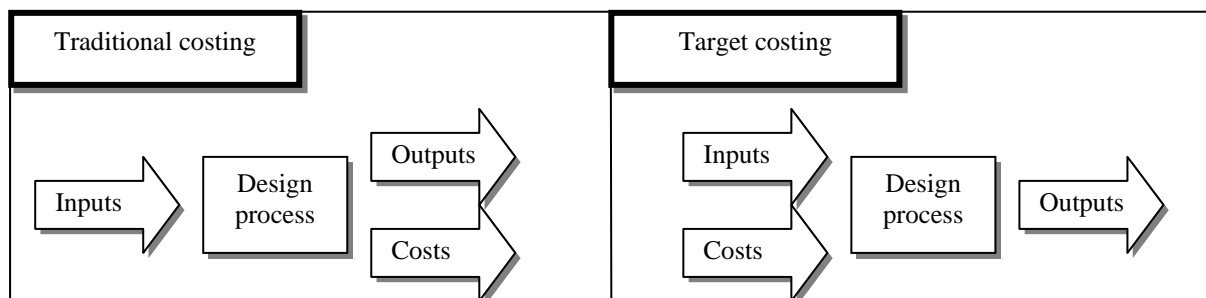


Exhibit 4.1 – Costs switch from outputs to inputs

As this article intends to blend target costing, activity based cost management and the theory of constraints, the maximum allowable cost has to consider not only the target selling price and the desirable margin of one product, but of the enterprise mix of products. That maximum allowable cost has to consider both activities driver's quantities available (and its costs) and the totally variable costs, such as direct materials and sales commissions.

5. Identifying profitable opportunities of products to design

In order to show how to combine what has been written by far, a example was developed and shows the situation of a enterprise losing money with today's capacity and product mix and two possible decisions that could have been taken in order to reverse that condition. The first is to design a product to better use today's given capacity and the second is to design a profitable product that will require a new capacity configuration. To simplify this analysis, differences between final cost objects entities other than products are not illustrated on that example. All table formats were inspired by the two products example on Baxendale and Raju (2004). Information from tables 5.2, 5.3 and 5.4 next are summarized on table 5.1 below.

	Today	Near future – design of a product for today's capacity	Future – design of a product for a future capacity configuration
Revenue	850.0	905.0	1,330.0
(-) Total variable direct costs	(180.0)	(195.0)	(300.0)
(=) Throughput	670.0	710.0	1,030.0
(-) Products costs	(483.0)	(547.0)	(744.0)
(=) Products profit	187.0	163.0	286.0
(-) Business Sustaining Costs (BSC)	(100.0)	(100.0)	(125.0)
(=) Result after BSC	87.0	63.0	161.0
(-) Unused capacity cost (UCA)	(92.0)	(28.0)	(61.0)
(=) Profit / loss before taxes	(5.0)	35.0	100.0
Fixed costs (products + BSC + UCA)	(675.0)	(675.0)	(930.0)

Table 5.1 – Comparison of fixed costs and an adapted profit and losses statement of different situations

This table shows a comparison between fixed costs and an adapted profit and lost statement of three different situations for a company, detailed on the next three tables of this paper. The first situation shows how the company is today, having an \$ 850 revenue from its products sales and a loss of \$ 5 after incurring all costs. To reverse that situation without reducing capacity or market share, the design staff could help the company by designing a product that would in the near future consume that \$ 92 cost of unused capacity and / or a profitable product that would require a new capacity configuration for the future. These options are illustrated respectively on the last two columns of this table.

The design of a product (product A) for better use of today's capacity would increase revenue, total variable direct costs and product costs, reducing products profit. But, it would also dramatically decrease the cost of unused capacity, increasing the company's profit before taxes. It is interesting to notice that the fixed costs do not change, what happens here is the improvement of capacity usage and because of that, even with the product profit decrease, the overall result is much better. As there is no increase on fixed costs, the \$ 40.0 throughput increment goes directly to the bottom line.

On the third situation – the design of a product (product B) for a future capacity configuration, shown on the last column of that table – much more time and a considerable investment (not shown here) are required. It also gives a tremendous profit before taxes and obviously represents a higher level of risk – not everything will come out as planned! Comparing with today, everything but unused capacity costs increases – suggesting that a capacity improvement is obtained by designing this product. Business sustained costs are \$ 25 higher due cost increases on activities not traceable to the final costs objects.

As said before, the following three tables detail table 5.1 with information concerning products mix, prices and total variable direct costs. The allocation from resources to activities

is not shown here and activities costs are traced to products and unused capacity using ABC methodology – activity cost divided by driver availability (DA) equals cost per driver unit (CDU), activity costs are CDU multiplied by driver quantity (DQ) used by activities (or left to unused capacity). Capacity not used can be seen also as a percentage of driver availability. The product profit is the difference between product throughput and operational expenses traced to products and its margin is its profit divided by its gross revenue.

As can be seen below on table 5.2, at today's situation, the operational expenses are traced only to unused capacity and to products X and Y that consume respectively \$ 208 and \$ 275 of the operational expenses. Although they are profitable products, their mix is not profitable after business sustaining costs and unused capacity costs. To design a product in order to better use its capacity, the company verified how much of its activities were unused – measured by unused capacity's drivers quantities – and what would have a market demand and could have been produced with it.

					Product X		Product Y		---				
Units produced and sold					400		600		0				
Unit Price					0.70		0.95		0				
Unit variable direct costs					0.15		0.20		0				
Gross Revenue					280		570		0				
(-) Total variable direct costs					60		120		0				
(=) Throughput					220		450		0				
(-) Operational expenses traced to products													
					DQ		Cost		DQ		Cost		
Activity	Driver	DA	Cost	CDU									
Proc. Order	# of orders	300	45.0	0.15	80		12.0		180		27.0		
Machine	Machine hours	400	200.0	0.50	140		70.0		200		100.0		
Assemble	Assembly hours	300	90.0	0.30	140		42.0		80		24.0		
Inspect	Inspection hours	250	200.0	0.80	80		64.0		140		112.0		
Transport	Volume (m3)	200	40.0	0.20	100		20.0		60		12.0		
Total oper. expenses costs					208.0		275.0		0.0		92.0		
(=) Product profit					12.0		175.0		0.0				
Product profit per unit					0.03		0.29		0.00				
Product margin					4.3%		30.7%		0.0%				
Revenue percentage					32.9%		67.1%		0.0%				

Note: DA, CDU, DQ and Proc. order stand for respectively driver availability, cost per driver unit, driver quantity and process order.

Table 5.2 – Today's product mix throughput, activity capacity usage and profit at product level

That is exactly what is on table 5.3 next, in which the company is producing and selling product A, not changing its capacity configuration neither reducing its other products' market share. ABM theory alone would probably find not applicable to produce this new not profitable product, although it increases the company throughput and profit with an extra \$ 40, by using some of the unused capacity left when there were only products X and Y. These benefits of introducing this product to the mix are visible with TOC. Comparing both tables 5.2 and 5.3, designing and manufacturing product A cuts \$ 24.0 from products total profit, what is equal to this product profit (- \$ 24.0). That \$ 40.0 bottom line increment showed before is because fixed costs do not change from one situation to the other and product A utilizes the difference between both totals costs of unused capacity (\$ 92.0 - \$ 28.0 = \$ 64.0).

On the other hand, TOC alone would not consider to design, produce and sell product B – exhibited on table 5.4. According to ABM, this is a very profitable product, but it does not fit today's given capacity profitably because consumes too much of an activity – inspect products – that would rapidly become a constraint for the system at today's given capacity.

					Product X		Product Y		Product A				
Units produced and sold					400		600		100				
Unit Price					0.70		0.95		0.55				
Unit variable direct costs					0.15		0.20		0.15				
Gross Revenue					280		570		55		=> Total = 905		
(-) Total variable direct costs					60		120		15				
(=) Throughput					220		450		40		=> Total = 710		
(-) Operational expenses traced to products					DQ	Cost	DQ	Cost	DQ	Cost	Unused Capacity (UCA)		UCA / DA
Activity	Driver	DA	Cost	CDU							DQ	Cost	
Proc. order	# of orders	300	45.0	0.15	80	12.0	180	27.0	20	3.0	20	3.0	7%
Machine	Machine hours	400	200.0	0.50	140	70.0	200	100.0	40	20.0	20	10.0	5%
Assemble	Assembly hours	300	90.0	0.30	140	42.0	80	24.0	50	15.0	30	9.0	10%
Inspect	Inspection hours	250	200.0	0.80	80	64.0	140	112.0	25	20.0	5	4.0	2%
Transport	Volume (m3)	200	40.0	0.20	100	20.0	60	12.0	30	6.0	10	2.0	5%
Total oper. Expenses costs		575.0			208.0		275.0		64.0		28.0		
(=) Product profit					12.0		175.0		(24.0)		=> Total = 163		
Product profit per unit					0.03		0.29		-0.24				
Product margin					4.3%		30.7%		-43.6%				
Revenue percentage					30.9%		63.0%		6.1%				

Table 5.3 – Product mix throughput, activity capacity usage and profit at product level with product A

Besides, making product B with today's capacity would require products X and Y manufacturing quantity reduction – leading to a decrease on market share participation, which is not always wanted by companies. That is why table 5.4 show a riskier but more profitable situation, with an increase of machine and inspection hours (and costs!) to fit product B's production. Capacity's changes can often require a considerable time to be implemented, that is why product B is to be produced and sold on the future.

					Product X		Product Y		Product B				
Units produced and sold					400		600		600				
Unit Price					0.70		0.95		0.80				
Unit variable direct costs					0.15		0.20		0.20				
Gross Revenue					280		570		480		=> Total = 1330		
(-) Total variable direct costs					60		120		120				
(=) Throughput					220		450		360		=> Total = 1030		
(-) Operational expenses traced to products					DQ	Cost	DQ	Cost	DQ	Cost	Unused Capacity (UCA)		UCA / DA
Activity	Driver	DA	Cost	CDU							DQ	Cost	
Proc. order	# of orders	300	45.0	0.15	80	12.0	180	27.0	20	3.0	20	3.0	7%
Machine	Machine hours	600	270.0	0.45	140	63.0	200	90.0	200	90.0	60	27.0	10%
Assemble	Assembly hours	300	90.0	0.30	140	42.0	80	24.0	50	15.0	30	9.0	10%
Inspect	Inspection hours	400	360.0	0.90	80	72.0	140	126.0	160	144.0	20	18.0	5%
Transport	Volume (m3)	200	40.0	0.20	100	20.0	60	12.0	20	4.0	20	4.0	10%
Total oper. expenses costs		805.0			209.0		279.0		256.0		61.0		
(=) Product profit					11.0		171.0		104.0		=> Total = 286		
Product profit per unit					0.03		0.29		0.17				
Product margin					3.9%		30.0%		21.7%				
Revenue percentage					21.1%		42.9%		36.1%				

Table 5.4 – Product mix throughput, activity capacity usage and profit at product level with product B

For both designing products A and B, target costing techniques are recommended to set the maximum allowable cost – total variable direct costs and product costs, always considering the company's capacity, capacity's requirements and product mix. If the mix was not to be considered, product A could not have been designed and the company wouldn't switch from a negative \$ 5 result to a positive \$ 35 without making capacity investments.

5. Conclusions and recommendations

It is well known from literature that TOC focuses on the enterprise survival today and that ABM promises its long term growth and continuance. This article brought these two theories together and its contributions to the design phase of a product life cycle with a simple didactic example. It also tried to show how target costing could be applied and employed with TOC and ABM. Most strategic decisions of a company must look at the future, but if short term decisions to help the company achieve this promised future are not taken, it might not come. Product design can and must help a business overcome today's difficulties and get ready for tomorrow's challenges and uncertainties.

Although this paper was based on both authors' professional experiences and on the references below, a longer work could explore the relations exposed on this paper at a case study at a real company. In addition to what has been written here, an upstream supply chain analysis would also be interesting in order to evaluate suppliers capacity to deliver parts demanded by products, these components costs and how its production would impact the suppliers' business – profit, growth and so on.

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