

## 16.3. Theory of Constraints: Product Mix Pricing and Costing

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### 1. INTRODUCTION

The managerial accounting mission is to provide decision takers and policy makers with information focused on controllable variables and their impact on company's performance. In order to comply its mission, important instruments of managerial accounting was introduced recently: *Activity Based Costing (ABC)* and *Throughput Accounting* (derived from *Theory of Constraints - TOC*).

The classical costing methods — absorption and direct — remain as means to elaborate formal financial statements and internal managerial team respectively, despite their limitations when applied in a company within fierce competitive markets. In the same way, the manufacturing environment has also changed, revamping processes and , consequently, changing the relative composition of industrial costs.

In the 80's, however, arisen academic studies stressing the lack of relevance managerial accounting was suffering to deal with the new competitive paradigm of a globalized world. The effects of misled decisions by traditional measures might (have) lead companies to a sub optimal position or even to a non-stop travel to bankruptcy.

ABC arises from the premise that products consume activities, and these consume resources. So, costs are generated by activities, like inspection, goods receiving, product dispatching, etc. The activities costs are attributed to all products according to the number of time they are handled or transformed by them.

To map all activities within a company is an almost impossible task, so in the real world they are joined in groups of activities (cost polls) and generally a non-financial indicator is chosen to determine the cost pool allocation. This indicator is called *cost driver*.

So, ABC consists essentially an improvement of the traditional absorption costing with a somewhat systemic approach. Notwithstanding, the concern to reach the "true product cost" remained. This obsession led many companies to get rid of many product lines of low volume which consumed many activities, leading them to concentrate their efforts on fewer products.

Also in the mid 80's, another approach started to be spread by books (*The Goal*, and other Goldratt's books) and specialized magazines like *Management Accounting*. Likewise ABC, this method can be interpreted as an improvement of the direct cost approach: costing derived from Theory of Constraints (TOC).

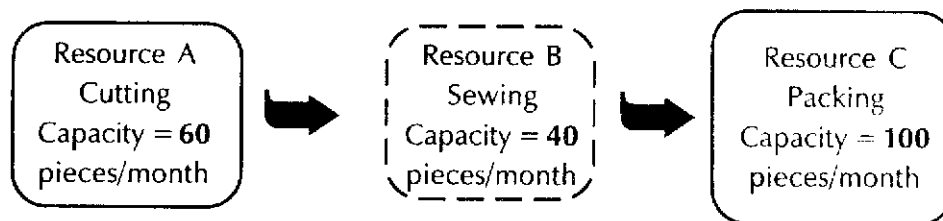
## 2. THEORY OF CONSTRAINTS

The methodological approach of the Theory of Constraints (TOC) was first presented by the book *The Goal*, in 1985. One of its authors was Eliyahu M. Goldratt. Novel-like written, this book describes the author experiences (personified by the character Jonah) in elaborating optimization methods for industrial processes. From then on, TOC expanded to other business fields, including the development of new tools for Managerial Accounting.

From the adoption of simple and logical concepts TOC established an effective integration between Accounting and Production, resulting on agile and efficient decisions, always having in sight the major objective of any business: to make money now and forever.

TOC is based on the concept of **constraint**: any obstacle that limits a better performance of the system toward the goal.<sup>1</sup> It is the factor that determines the performance of the whole system and are commonly known as '*bottlenecks*'.

For example, suppose that in a clothes company there are 3 (three) production resources (machines or workers), set up as this production flow chart:



Taking for granted that the market will absorb any quantity of clothes pieces, the 'capacity constraint resource' is B. So, if is ordered an amount of production greater than 40 pieces/month, the net effect will be a greater stock of materials in process and not in greater sales. Such increase in stocks will add to assets (investment) without resulting throughput, increasing expenses with storage and handling of the excess materials. By the other side, if company decide to produce at maximum 40 pieces per month, the market will buy them all with no increase on expenses even if resources A and C would remain idle.

TOC has a simple recipe for managing constraints: the process of ongoing improvement (in five steps).

<sup>1</sup> Two types of constraints can be classified (1) physical, those related with materials supplying, productive capacity, logistics and even market demand; and (2) non-physical, or political, related to managerial policies and habits, spread throughout the company by norms, orders and crystallized habits.

1. Identify the system's constraint(s);
2. Decide how to exploit the system's constraint(s);
3. *Subordinate everything to the above decision;*
4. *Elevate the system's constraint(s); and*
5. If a step have been broken, go back to step 1. Do not allow inertia to cause a system constraint.

In our previous example, the factor that limits the system performance as a whole is the machine B (or worker B, from sewing). Identified the constraint the management have to find out how to make the best of it, like to not allow to sew pieces with cutting defects; avoid making the constraint idle waiting for raw material or making break for lunch. After that we have to subordinate all resources non-constraints (A-cutting and C-packing) at the speed of the constraint (B-sewing), supplying only the enough to keep B working and the its buffer stable.

After we are sure that we cannot make any improvement exploiting better the constraint, the company should increase its physical capacity, acquiring another machine or modifying in order to enhance its capacity. We should increase the capacity of the constraint resource until it won't bring an increase on sales. At this point it means that the constraint isn't anymore resource B and might be another one or even the market, forcing us to go back to step one.

Still having in mind our example, we verify that some conclusions are quite obvious:

- ⇒ *One hour missed by a constraint resource represents one hour missed for the whole system* - If B doesn't work an entire day, 2 pieces won't be produced by the company (40 pieces divided by 20 working days), reducing the maximum level of 38 pieces for that month.
- ⇒ *One hour saved in a non-constraint resource is just a mirage* - To save operation time on resources A and C is irrelevant, since both are not constraints. The idleness of these resources doesn't change system's throughput, but they can contribute to reduce operating expenses;
- ⇒ *The utilization level of one non-constraint resource is not determined by its own potential, but by any other system's constraints* - B resource capacity level determines the entire system capacity, though A and C sometimes could remain idle;

Although empirically simple and logic, such verifications hide a classical conflict between two 'worlds' struggling inside organizations: the throughput world and the costs world.

### 3. THE THROUGHPUT WORLD (TOC) AND THE COSTS WORLD (ABC AND ABSORPTION)

TOC regard as "Throughput World" the method that is concerned with constraint(s) and is company's throughput oriented. And "Costs World" is regarded as the costing methods that gives the same importance to all units or process in a company, and they are costs and expenses oriented.

If a company is compared to a chain let's see how those "Worlds" would analyze it. Broadly, the main objective of any chain is to *transmit power without breaking itself apart*. In the costs world the main performance measure consists on the concept of standard cost and variances analysis, which in our analogy would correspond to *chain weight*. To control production standard cost in order to reduce total cost is analogous to chain weight shrinkage, by a reduction of some *link*.

**Costs World:** Any improvement at any chain link make the whole chain better. Weight (operating expenses) reduction enhances chain performance. *The more we improve locally the more we have a global enhancement.*

According to what is stated above, if we were to improve A and C resources performance at costs world's view we should increase their output in order to dilute their costs in more pieces, so that the unit cost of each piece would fall. But as we have already seen this attitude will just elevate stocks and expenses not throughput and profit.

On the other hand, in the throughput world the firm is composed by sub-systems (links), and the decisions must aim the whole chain resistance enhancement and not its weight reduction. Therefore only strengthening the weakest link would improve the chain performance. In another words:

**Throughput World:** Only improvement at constraint link(s) get the whole chain better. *The global improvement differs from the sum of locals improvement.*

Actually, in the traditional view we should seek the *maximum* production resources *efficiency* - scale economy - *reducing* at maximum *its product unit cost*. In addition, emphasizing resources optimization might lead to *higher level of inventories*.

In TOC's view *only constraint resource full capacity utilization* will determine the *optimal global performance*. Keeping the maximum efficiency of this resource - *even causing idleness to the others* - the proceeds would remain the same, but the inventories reduction enhances company's Return on Investment (ROI). Besides that, it releases financial resources to cash flow and/or productive investment.

#### 4. TOC PERFORMANCE MEASURES

For TOC, *companies are systems* which have interdependent parts (resources and/or processes) within them. What matters is *the system performance, not its parts*'.

If a resource doesn't have any alternative use than working for the next process and it's not a system's constraint, it should be idle sometimes to avoid raising stocks (and expenses). But if there is alternative use and if it provides any positive unit throughput, is highly recommended to exploit it in order to improve whole system's throughput.

Therefore the only way you can evaluate products, production resources and activities is analyzing their impact on *system's capacity to "make money"*. How can we measure it? We have three fundamental measures:

1. **Net Profit (NP)**: this is an absolute "making money" measure. It shows the amount of money the system creates.
2. **Return on Investment (ROI)**: it is a ratio between net profit of a period and the amount of investment. With this measure we can compare the company performance to any kind of investment. The bigger NP is the greater ROI is, and the bigger I is the lesser ROI is.
3. **Cash Flow (CF)**: this is not a measure is a kind of alarm. When the company have enough cash or liquid assets to comply its compromises it doesn't matter, but when it doesn't nothing else matters. Companies go bankrupt not because they are not profitable but because they can't manage to pay their bills.

Although these measures are enough to figure out how much money the system is making, they don't help us to judge the impact of our actions/decisions on our goal. For example, the optimum batch size, the optimal product mix, and so on. We have to achieve such measures with which we can judge *the impact of a local decision/action on the company's goal*.

According to TOC we can't find such measures in the traditional managerial accounting. Below is described the three main TOC measures with which we can evaluate the whole system.

1. **Throughput (T)**: is the amount at which the system generates money *through sales*. In accounting terms is the difference between gross sales and 'totally variable costs' (raw-material, sales taxes and commissions for example). "Direct labor cost" is not considered by this measure because it is not totally variable with regard production. Only if laborers should be paid by their production it could be regarded as totally variable.
2. **Operating Expenses (OE)**: Every cost and expense made in order to transform raw-material into finished products, since they are not 'totally variable' with regard production/sales level.
3. **Inventory (I)**: all the money the system *invests* in purchasing things the system pretend to sell

These new measures are related with the global measures as is stated below:

$$NP = T - OE$$

$$ROI = NP / Investment$$

## 5. THE THROUGHPUT ACCOUNTING (TOC) AND THE OTHER COSTING METHODS

The main difference between Throughput Accounting and the other methods is that TOC doesn't allocate any kind of indirect cost and expense to product level. In table 1 is represented the major costing methods: Absorption, ABC, Direct and Throughput Accounting.

Any sort of allocation is set over a rigid level of production and product mix. If we intend to make projections or simulations for the (near) future using data from allocation based costing we have to be aware that the figures we reach might be distorted.

Besides that, the allocation based costing considers costs as "inventoriable", i.e., instead to be stated directly into the income statement, they are "absorbed" by products, increasing inventories' values. It's a manner to "hide" expenses. Therefore, these kind of costing method do incentive materials in process and final products inventories to be piled up.

The *Total Quality Management (TQM)* and *Just-in-Time (JIT)* leaders reckoned that cost accounting mentality was a great obstacle to implement the *Quality Revolution*. When they said to shrink inventories is more important than letting some resources idle, "cost accounting mentality" reacted to that, because it was against the notion of *maximum efficiency in productive resource utilization*. Although TQM and JIT became the new paradigm in manufacturing, they haven't created nothing to replace the traditional managerial accounting methods. That's what throughput accounting intends to be, a simple method that anybody in a company would be able to understand the link between his/her actions with the company's performance. Allowing and stimulating every laborer to accomplish the organization's **goal** (to make money now and forever).

According to TOC, only Throughput is determined by unit of product; it has a sales price and the amount of money spent to buy the quantity of raw-material that was used to make it, so we have its throughput. TOC consider that any sort of *non-totally variable cost* (or expense) allocation to products is arbitrary, i.e., can change accounting information depending only on which indicator is chosen to determine cost allocation. Operating expenses can be attributed to categories not to products, like production laborers, rental, telephone/power bill, etc.

By the fact that Throughput Accounting doesn't make any kind of allocation, it is more flexible to make budgets, project forecasts and simulate decision impacts on company's performance.

Table 1: Costing Methods Comparison

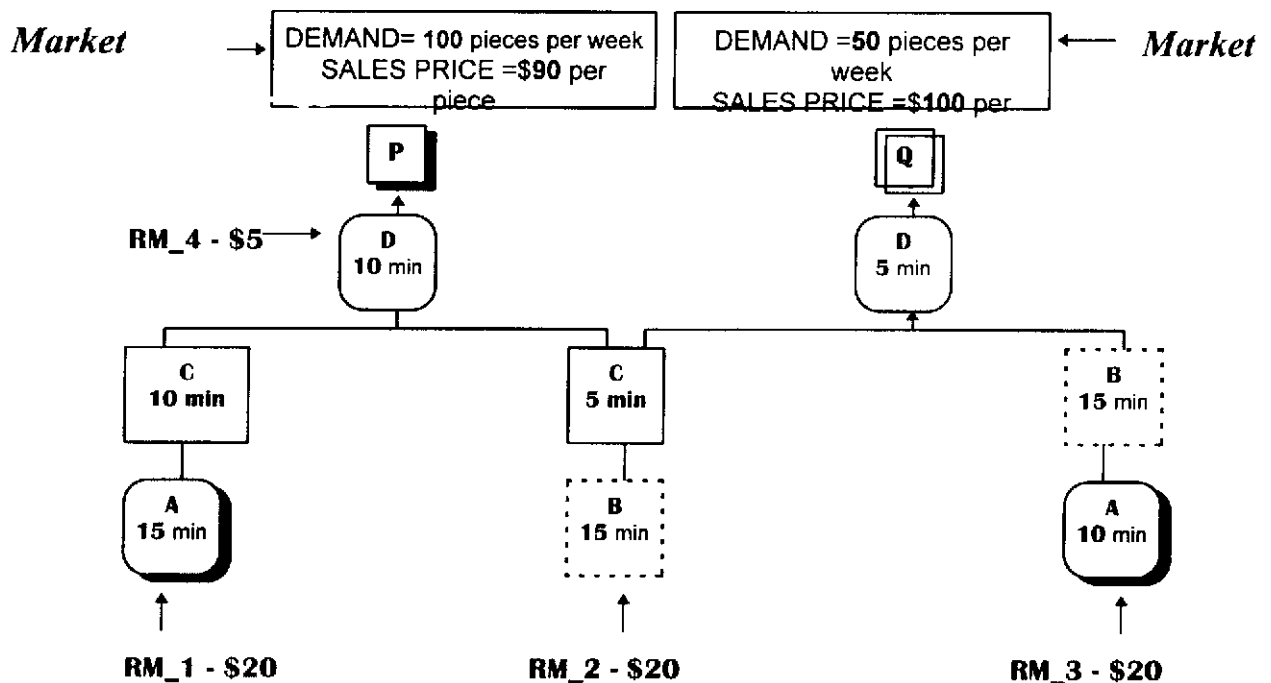
Absorption Costing	ABC	Direct Costing	Throughput Accounting (TOC)
Unit Net Sales Price	Unit Net Sales Price	Unit Net Sales Price	Unit Net Sales Price
(-) Unit Direct Materials Costs	(-) Unit Direct Materials Costs	(-) Unit Direct Materials Costs	(-) Unit Totally Variable Costs
(-) Direct Labor Costs per Unit of product	(-) Direct Labor Costs per Unit of product	(-) Direct Labor Costs per Unit of product	
	(-) Allocated Indirect Cost Pool 1	(-) Unit Variable Cost and Expenses	
	(-) Allocated Indirect Cost Pool 2	<b>(-) Unit Contribution Margin</b>	<b>(-) Unit Throughput</b>
	(-) Allocated Expenses Pool K		
	(-) Allocated Indirect Cost Pool N		
(-) Unit Allocated Indirect Costs	(-) Unit Allocated Indirect Costs		
<b>(=) Unit Gross Margin</b>	<b>(=) Unit Gross Margin</b>		
(x) Units sold per Product	(x) Units sold per Product	(x) Units sold per Product	(x) Units sold per Product
		<b>(-) Total Contribution Margin</b>	<b>(-) Total Throughput</b>
(-) Total Gross Margin	(-) Total Gross Margin		(-) Current Direct Labor Costs
(-) Other Current Expenses	(-) Other Current Expenses	(-) Indirect Fixed Costs	(-) Indirect Costs
(-) Total Net Profit	(-) Total Net Profit	(-) Other Current Expenses	(-) Other Current Expenses
		<b>(-) Total Net Profit</b>	<b>(-) Total Net Profit</b>

## 6. SIMULATION: INDUSTRY P&Q

Now we will see an example that will contrast the effects of decisions taken under Absorption, Direct, ABC and TOC approaches.

The industrial company P&Q Ltd. produces and sales the products P and Q. In order to avoid any kind of analysis bias let's consider that this firm works in ideal conditions ,i.e., its purchasing market buys all output, it doesn't change its demand, there is no shortage of raw-material, the machines doesn't break down and there is no waste material.

The demand for product P corresponds to 100 units per week, at the unit price of \$90, while Q is weekly demanded 50 pieces by \$100 per each. The firm has machines A, B, C and D to transform raw-materials RM1, RM2, RM3 and RM4 into finished products. The first three cost \$20 per product unit, while RM4 cost only \$5 per finished product. The process flows, prices, quantities and production spending time are in the figure below:



Further informations:

- The firm has just one unit of each resource and no resource is able to do the job of any other machine;
- Each resource is disposable only 8 hours a day, five days a week, summing 2,400 minutes per week (8 x 5 x 60);
- The weekly expenses are:

Costs Categories	Description	\$ per Week
Direct labor cost	4 workers, 40 hours week costing \$5 each	800
Indirect production costs:	Other Indirect Costs and Expenses	5,200
<b>Total</b>		6.000

The problem to be solved is : Which product mix would maximize P&Q's weekly net profit?

Following absorption costing the higher is the product *gross margin* the higher is its priority. At direct costing point of view, is given higher priority to those with higher *contribution margins*. ABC gives importance to products according to its *gross margin*, which is defined as sales revenues minus direct costs and weighted total indirect costs (by consumption of activities). At last, TOC's criterion is a ratio of the product unit throughput and how much time the bottleneck resource spends to produce one unit of it. In other words, TOC pursue the *throughput per bottleneck minute spending maximization*.

Below are shown how each method "solve" this problem.

#### Exhibit I -Traditional Approach ( Absorption/Direct Costing)

	Unit		Total		
	P	Q	P	Q	P + Q
Quantity			100	50	
Sales Revenues	90.00	100.00	9,000	5,000	14,000
Raw-Material	(45.00)	(40.00)	(4,500)	(2,000)	(6,500)
Direct Labor Costs - DLC (*)	(5.50)	(5.00)	(550)	(250)	(800)
<b>Contribution Margin(Direct Costing)</b>	<b>39.50</b>	<b>55.00</b>	3,950	2,750	6,700
Indirect Costs and Expenses(**)	(35.75)	(32.50)	(3,575)	(1,625)	(5,200)
<b>Gross Margin(Absorption Costing)</b>	<b>3.75</b>	<b>22.50</b>	375	1,125	1,500

(\*) Direct Labor Costs(DLC)

	P	Q	Total
Labor minutes per unit	55	50	105
Quantity	100	50	150
Total minutes	5,500	2,500	8,000
%	68.8%	31.3%	
Total DLC	\$550	\$250	\$800
Unit DLC	\$5.50	\$5.00	

(\*\*) Indirect Costs and Expenses → in proportion to DLC

As we can see, in Exhibit I, both methods, direct and absorption, consider that product Q is the most profitable at a production level of 100 Ps and 50 Qs. Below in Exhibit II, is shown how an ABC approach could be done:

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**Exhibit II. Activity Based Costing (ABC)**  
**Approach**

**i) Indirect Costs and Expenses Categories**

<b>Cost Pools</b>	<b>\$ Per week</b>
<b>Purchasing</b> (Goods Receiving, Inspection, Material Handling, Registering)	1,040
<b>Production</b> ( Production Supervision, Equipment Depreciation and Rental)	3,380
<b>Sales</b> ( Marketing, Products Expedition)	780
<b>TOTAL</b>	5,200

**ii) Cost Drivers**

	<b>P</b>	<b>Q</b>	<b>TOTAL</b>
<b>a) Purchasing - Volumes Receipt per Week</b>	5	3	8
Purchasing Activity Costs Allocation	650.00	390.00	1,040.00
<b>Unit Costs</b>	<b>\$6.50</b>	<b>\$7.80</b>	

<b>b) Production</b>	<b>A</b>	<b>B</b>	<b>C</b>	<b>D</b>	<b>TOTAL</b>
Production Supervision	\$470.00	\$470.00	\$470.00	\$470.00	\$1,880.00
% according to relative time spent	25%	25%	25%	25%	
Equipment Depreciation and Rental	\$375.00	\$562.50	\$328.13	\$234.38	\$1,500.00
% according to machine-hour	25%	38%	22%	16%	
<b>TOTAL</b>	<b>\$845.00</b>	<b>\$1,032.50</b>	<b>\$798.13</b>	<b>\$704.38</b>	<b>\$3,380.00</b>

Resource minutes spending per unit of product (Machine Hours = Labor Hours)

<b>Resources</b>	<b>P</b>	<b>Q</b>	<b>TOTAL</b>	<b>100</b>	<b>50</b>	<b>TOTAL</b>
A	15	10	25	1,500	500	2,000
B	15	30	45	1,500	1,500	3,000
C	15	5	20	1,500	250	1,750
D	10	5	15	1,000	250	1,250
<b>TOTAL</b>	<b>55</b>	<b>50</b>	<b>105</b>	<b>5,500</b>	<b>2,500</b>	<b>8,000</b>

Costs allocation according to resource time spending per unit of output

<b>Resources</b>	<b>P</b>	<b>Q</b>	<b>Total</b>
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A	\$633.75	\$211.25	\$845.00
B	\$516.25	\$516.25	\$1,032.50
C	\$684.11	\$114.02	\$798.13
D	\$563.50	\$140.88	\$704.38
PRODUCTION costs allocation	\$2,397.61	\$982.39	\$3,380.00
<b>Unit Cost</b>	<b>23.98</b>	<b>19.65</b>	

**c) Sales - Requests per week**

SALES costs allocation

P	Q	TOTAL
10	7	17
\$458.82	\$321.18	\$780.00
<b>Unit Cost</b>	<b>4.59</b>	<b>6.42</b>

<b>Unit Indirect Costs - Summary</b>	<b>P</b>	<b>Q</b>	<b>TOTAL</b>
a) Purchasing	\$6.50	\$7.80	\$1,040
b) Production	\$23.98	\$19.65	\$3,380
c) Sales	\$4.59	\$6.42	\$780
<b>Total</b>	<b>\$35.06</b>	<b>\$33.87</b>	<b>\$5,200</b>

iii) Demonstrative	Unit		Total		
	P	Q	P	Q	P + Q
			100	50	
Sales Revenues	90.00	100.00	9,000	5,000	14,000
(-) Raw-Material	(45.00)	(40.00)	(4,500)	(2,000)	(6,500)
(-) Direct Labor Costs	(5.50)	(5.00)	(550)	(250)	(800)
	<b>39.50</b>	<b>55.00</b>	3,950	2,750	6,700
(-) Indirect Costs and Expenses	(35.06)	(33.87)	(3,506)	(1,694)	(5,200)
<b>Gross Margin</b>	<b>4.44</b>	<b>21.13</b>	444	1,056	1,500

Like the previous analysis, Q is the most profitable product in ABC's view (Exhibit II). Is good to stress that even with another allocation criterion with regard Absorption method, ABC can reach the same conclusions.

The new question is: *Can it be produced 50 Qs and 100 Ps? If not, which product mix would maximize company's profit?*

### Exhibit III - Optimization Analysis

#### i). Production Capacity

Production Capacity Calculus	P (min)	x 100	Q (min)	x 50	Total	max = 100 %
Resource A	15	1,500	10	500	2,000	83%
<b>Resource B</b>	<b>15</b>	<b>1,500</b>	<b>30</b>	<b>1,500</b>	<b>3,000</b>	<b>125%</b>
Resource C	15	1,500	5	250	1,750	73%
Resource D	10	1,000	5	250	1,250	52%

Since it is not possible to do that, and according to previous studies, we should give priority to Q production, because it has higher margin than P. So let's keep Q production at its demand level and adjust P production to company's maximum capacity.

#### ii) "Costs World" Optimization

##### a) Resource B (system's constraint) capacity utilization

##### Giving priority to Q (Supply = Demand)

B production minutes for 50 units of Q	1500	<b>Optimizing Mix</b>
B remaining minutes for P (2.400 - 1.500)	900	P (u) = <b>60</b>
P residual production (900min./15min.p/unit)	60	Q (u) = <b>50</b>

Determined product mix, let's see company's income.

Determined product mix, let's see company's income.

##### b) Mix Optimizing Results

Managerial Income Statement	\$/u	\$/u	\$ Total
Unit Sales Revenue (Price)	90.00	100.00	
Raw-Material Unit Cost	(45.00)	(40.00)	
Unit Contrib. Margin (minus DLC and PIC)	45.00	60.00	
Produced and Sold Units	<b>60</b>	<b>50</b>	
Contribution Margin (minus DLC and PIC)	2,700	3,000	5,700
Total DLC + Total PIC			(6,000)
<b>Net Loss</b>			<b>(300)</b>

As we verify, giving priority to the product with the highest margin doesn't provide positive profit in this case. *Is it possible to strive another way?*

Throughput Accounting approach is presented below.

#### IV - Theory of Constraints (TOC) Calculus

	P	Q	TOTAL
Unit Sales Revenue (Price)	90.00	100.00	
Totally Variable Costs (TVC)	(45.00)	(40.00)	
Unit Throughput	<b>45.00</b>	<b>60.00</b>	
Strategic Ranking	2nd	1st	
CCR minutes spending per unit	<b>15</b>	<b>30</b>	
Unit T per CCR minute spending	<b>3.00</b>	<b>2.00</b>	
New Strategic Ranking	1st	2nd	
Total CCR minutes spent per Product	1,500	900	
TOC Optimizing Mix (units)	<b>100</b>	<b>30</b>	
Total Throughput	4,500	1,800	6,300
Operating Expenses (DLC + PIC)			(6,000)
<b>Net Profit</b>			<b>300</b>

Surprisingly, not giving priority to the highest margin product can provide a higher profit. But *why?* The reason is how much throughput a unit of product generates per time spent in the constraint resource. In this case product P generates \$3 per minute spent in the capacity constraint resource (CCR), which is B, while Q generates only \$2.

## 7. CONCLUSION

The speed of economical change is accelerating more and more. The national markets globalization is making companies to elevate their productivity level in order to increase their market share or just to survive. But elevate productivity doesn't mean necessarily to elevate every resource or process productivity, it means to increase the company's productivity as a whole.

Although the factories' shop floor has suffered a lot of transformation towards *lean production* and *just-in-time*, traditional management accounting hasn't been able to provide meaningful information to this new business world paradigm.

It was in this context (mid 80's) that arose the *Activity Based Costing* (ABC), proposing a new approach on indirect costs allocation methods, based on the verification that the proportion of this kind of costs became more important than the direct ones, because of automation and other technological production improvements.

Besides that, ABC can be regarded as a precursor for *Reengineering* movement. It maps all activities and their expenses within a company, being almost a pre-requisite for a reengineering process. TOC's approach comes from production optimizing techniques. That's why it introduced the concept of constraint resource into Managerial Accounting. With this new concept all management information (including accounting) can be more focused on what really matters, i.e., on what is limiting company's performance, giving more efficiency to decision process.

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