USING OF THROUGHOUT ACCOUNTING IN MANUFACTURING COMPANIES – CASE STUDIES

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Abstract
In the article using of throughout accounting in manufacturing companies was presented. Authors solved the example according to the traditional approach, that is with application of measures used universally in the cost accounting and then according to new approach, with application of measures proposed by the theory of constraints. It was shown that based only on unit costs and a local productivity while analyzing profitability of investment isn’t possible because we should take care of importance of the given source into account from a point of view of the purpose which the organization want to achieve.

Keywords
throughput accounting, throughput, investment, operating cost, theory of constraints.

Introduction

Strong competitiveness, common use of modern technologies and constantly changing customers’ needs make it difficult for a productive company to keep its position on the market. Therefore, a company needs to improve its production systems [1]. It is connected with constant introduction of changes and these changes entail expenses. Inappropriate investment of company’s funds can weaken company’s position considerably or even make it bankrupt. Therefore, it is very important to conduct an analysis of investment efficiency, which aims at improving production process, with the help of appropriate standards which include company’s constraints. At present it is believed that improving production processes should lead to decreasing individual costs, shortening the time of a product presence in a company and maximum exploitation of production system’s supplies. In practice, the most often used tool for evaluation of production investments efficiency is costs count [2]. The problem with costs count is the fact that most costs are not at present directly connected with the size of production. Usually it is the material costs which show such connection. It makes approximation ensured by allocation not acceptable. It is caused by the fact that through years the nature and structure of costs in companies have changed immensely [3]:

- portion of labour in all-in costs decreases drastically (in many cases it does not exceed 10%) and workers are less and less often paid by the job,
- the most significant cost of a company is general costs (still allocated on products according to labour key).

Managing Accounting tried to solve these problems by improving existing paradigm. The theory of costs count has been widened creating new complex methods which are still based on the same rules. The literature of the subject matter assumes that the problem is caused due to allocating costs using only one activity measurement - labour. Using only one activity measurement, direct labour hours,
limits the ability to foresee cost changes together with changing size and variability of real production [4]. Nowadays cost accounting allocates costs also on the basis of measurements different than those concerning only activities connected with production size.

Cost accounting is outdated not because it uses only one activity measurement when allocating costs but because the allocation is done. Allocation is archaic because allocated costs, no matter which method is used, do not change exactly with the size and variability of production or any other variable [5]. Thus, allocation brings only confusion and prompts us to make irrational decisions, which is proved by Koliński, Trojanowska and Pająk in their publication [6].

Throughput accounting has been created in response to the aforementioned problems. It is based on the rules of Theory of Constraints.

An analysis of the example shown in Chapter 3 will help to assess the validity of this attitude.

TOC paradigm as the basis of throughput accounting

Main assumptions of TOC

Theory of Constraints (TOC) was published for the first time in 1984 in the book The Goal: Excellence in Manufacturing and it was created by a Hebrew PhD physicist Eliyahu Moshe Goldratt. The Theory of Constraints is a new paradigm of running a business. However, the present manuscript will show the theory in relation to problems of productive companies in a financial aspect. Theory of Constraints focuses on system improvement which is define as a series of independent processes. An analogy for a system is chain. Chain means a group of independent links working together toward the overall goal and a weak link is the constraint [1]. TOC assumes that it is possible that there is one cause which has many negative effects. This cause is limiting the system which is divided into external (not depending on a company) and internal. It needs to be pointed out that the constraint connected with company’s policy and strategy constitutes even 90%, while the constraints connected with the supplies comprise only 8% [7]. The element of a system which bandwidth determines the efficiency of the whole system is called a bottleneck. Every system has at least one constraint [8]. Finding this element is the basis for improving the production system which, according to TOC, is composed of five steps and is some kind of cycle. The five focusing steps:

- Identify system’s constraint: The first step on the way to perfection is finding and accurate pointing to system’s supply which limits global efficiency. According to TOC, it is this particular supply where changes should be introduced as improving other elements of a system and improving local efficiency will not lead to improving whole system’s efficiency because it is the weakest link which affects global efficiency.
- Decide how to exploit system’s constraint: The second step of TOC points one’s attention to the fact that the supply identified as system’s constraint should be exploited to its maximum. Such exploitation can be achieved thanks to bottleneck’s constant work. An increase in bottleneck’s exploitation can be also achieved by moving some activities to other less loaded work posts which are technologically adapted to doing these activities [9].
- Subordinate everything else to the above decision: Previous step has made system’s constraint work with maximum efficiency so step 3 is to adjust the pace of other elements to constraint’s pace of work. Otherwise, if we allow other elements to produce faster and more, we are going to generate expenses. It can increase local efficiency but it will not help in increasing the overall process.
- Elevate system’s constraint: Step 2 and 3 are very important in TOC as they contribute to sorting the system. There are still, however, many methods to increase production and improve the system. Step 4 of TOC allows for investments which contribute to increasing the efficiency of the whole system by strengthening the constraint. It can be achieved by increasing the number of annual shifts.
- If in the previous steps a constraint has been broken, go back to step 1, but do not allow inertia to cause system’s constraint: Breaking the constraint should be achieved by a constant increase in the efficiency as a result of realising step 4. Then another supply which limits system’s prospects should be found. Discussed steps have been shown in Fig. 1 as a process of constant improvement.

![Fig. 1. The process of continuous improvement in TOC. Source: Own Study.](image-url)
Realising the steps, or actually TOC cycle, in appropriate way will make the constraints stop be perceived as something bad. On the contrary, they will become a chance for developing a company. Nevertheless, a bottleneck should not be ignored “There is really no choice in this area. It is us who manage the constraints. Otherwise, the constraints can manage us. Constraints will determine the size of production whether we will acknowledge their existence and manage them or not” [10].

The measurements of effectiveness used by Throughput Accounting (TA)

If we know the aim of existence of a given organisation, we can define measurements which will allow us to assess the effects of individual subsystems’ activities and their influence on achieving a global aim. The measurements of efficiency used in TOC have a financial character thanks to which it is easy to assess whether the decision has been made will bring the company forward to achieving the global aim.

The measurements of effectiveness used by throughput accounting:

- Throughput ($T$), in other words pace with which a system generates money through sales. It is important to realise that production means gaining ‘fresh’ money (out of a company) and this money is generated by sales and not by the production itself. That is why the definition of production includes the phrase ‘by sales’. One of the methods to increase throughput is increasing the number of sold products [3]. Unit production ($T_u$), is calculated by subtracting totally variable costs of a given product ($TVC$) from the price ($P$), which is illustrated in equation (1):\[ T_u = P - TVC. \] Totally variable costs are the part of the costs which change together with the size of sales. It is every cost which changes proportionately with the size of production. Taking into account the general aim of a company, which is making money, it can be stated that production is the first derivative of a system’s aim in terms of time. Meanwhile, total production on a product ($TT_p$) in a given period can be calculated by multiplying unit production ($T_u$) by the quantity ($q$) of a product that was sold in the analysed period. It is shown in equation (2):\[ TT_p = T_u \times q. \] In order to calculate total production of a company in a given period one needs to add all the results from equation (2) for individual products.

As can be seen from the presented examples production is not synonymous with profit.

- Investment ($I$), in other words the money that a system has spent to buy what it intends to sell. The way to reduce investment is to sell something a company has bought and not increasing other investments at the same time [3]. As regards managing production we can name four kinds of elements which comprise investment and these are: supplies of materials and resources; work in progress; finished goods; other resources (e.g. buildings, land, machines, etc.). It can be concluded that investments are not synonymous with the commonly known term of asset. One can be surprised at the elements which constitute an investment as the definition tells us about the elements which are going to be sold. Ranking land, machines, office equipment, etc. as investment is caused by the fact that selling company’s shares we are in fact selling some part of machines, land, etc.

- Operating expenses ($OE$), that is to say the money spent by the system to change investment into throughput. TA does not differentiate between fixed and variable expenses and between direct and indirect expenses. That is why operating expenses include all expenses except those completely variable which are investment. $OE$ can include expenses connected with energy, lease and pay. In order to reduce operating expenses we need to reduce company’s expenses [3]. Using given measurements the equation for net profit ($NP$) looks like this (3):\[ NP = T - OE. \] While using the traditional equation of expenses net profit in a given period is calculated as the difference between total revenue from each individual product, total cost of raw materials constituting these products and total operating expenses which belong to different categories and are necessary to keep a company in movement. Allocation has made decision-making easier but it has been an appropriate attitude when most expenses were dependent directly on the size of production [11]. The rate of return from investment, when using the measurements of TOC, takes the following form (4):\[ ROI = \frac{NP}{T}. \] $ROI$, in a traditional expenses equation, is the rate of profitability used in order to measure the efficiency of a company, regardless of the structure of its means or any unusual factors, while using TOC, the influence of any decision on company’s financial product is defined on the basis of three
measurements: $T$, $I$ and $OE$ taking also into account the fact that each decision that influences $ROI$ positively is a decision which helps a company to realise its aim [3].

Algorithm

The present subchapter presents author’s algorithm for assessing investment efficiency using throughput accounting. Using presented algorithm one can get information about the profitability of an analysed investment. After analysing individual investments with the use of this algorithm it is possible to choose the best options by comparison of $ROI$ values. The most profitable investment would be the one with the highest $ROI$ value.

**Fig. 2. Algorithm. Source: Own Study.**

**Case study**

**Description of the case**

A company producing cog wheels has been analysed. To simplify we have assumed that:

- production process includes only five operations,
- the demand for produced goods is much more bigger than productive capabilities of the company,
- the company works 8 hours a day for 22 days a month.

Let us assume that the company sells only cog wheels, selling price of one cog wheel is 50 Euros and the cost of material for one wheel is 15 Euros. Monthly cost of company’s maintenance is 100 000 Euros.

Figure 3 presents a diagram of the process together with the efficiency of individual operations.

**Fig. 3. Scheme of production process. Source: Own Study.**

An analysis of figure 3 allows identifying a constraint, that is a factor which determines the bandwidth of the whole system. In the analysed example it is operation no 3 as it has the lowest efficiency (40 units per hour). It means that due to the present shape of the production system it is possible to produce maximum 40 units in an hour.

Production manager has suggested introducing an improvement which will result in increasing the efficiency of operation no 2. Introducing the suggested change will entail purchase of additional equipment, which will affect the value of one of the measurements used in TOC (investment). The value of investment will increase by 5000 euro ($I_2$) and, at the same time, the efficiency of the operation will increase from 50 to 53 pcs/h.

Manager’s assistant has suggested introducing a different improvement which will increase the efficiency of operation no 3 from 40 pcs/h to 41 pcs/h and, at the same time, decrease the efficiency of operation no 5 from 50 to 46 pcs/h. Introducing these changes will result in increasing investment by 10 000 Euros ($I_2$).

What decision should be made by a company’s management? Which improvement should be implemented?
Introduction of the traditional attitude of cost count

It very often happens that when solving such a problem one needs to take into account minimising the costs of producing a product. It is caused by the fact that while increasing the price could entail losing customers, decreasing the expenses is the only way to increase the profit, which is shown in Fig. 4. The cost of a product depends mainly on how much time it spends in a company absorbing, at the same time, its resources. That is why shortening this time will have a positive effect in the form of decrease in product costs. This can be achieved by shortening the time of one of the operations.

![Fig. 4. Cutting cost means increase profit. Source: Own Study [12].](image)

Analysing manager’s suggestion we can conclude that the time spent in a company by an individual product will be shortened as increasing the efficiency of operation no 2 means that the introduced improvement will make this operation faster.

Similarly, analysing manager’s assistant’s suggestion we can conclude that the time spent in a company by an individual product will be lengthened as increasing the efficiency of operation no 3 will lengthen the total time by about 4 seconds. The calculations are presented in Table 1.

<table>
<thead>
<tr>
<th>Table 1</th>
<th>Effect of time changes of productions process – assistant proposition.</th>
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<tbody>
<tr>
<td></td>
<td>Before changes</td>
</tr>
<tr>
<td>Operation no. 3</td>
<td>40 units per hour means 1 units in 90 seconds</td>
</tr>
<tr>
<td>Operation no. 5</td>
<td>50 units per hour means 1 units in 72 seconds</td>
</tr>
<tr>
<td>Total time for operation 3 and 5</td>
<td>162 seconds</td>
</tr>
</tbody>
</table>

In addition, it needs to be pointed out that assistant’s suggestion is twice as expensive as manager’s.

To conclude, with the use of present measurements and commonly used method of solving this kind of problems (which is, of course, connected with using a cost count in productive companies) assistant’s suggestion is going to be turned down and manager’s suggestion is going to be put into practice.

Introduction of the attitude of throughput accounting based on the algorithm

When solving the problem one needs to remember what the aim of the company is and how the suggested changes will influence gaining this aim. The main aim of a company is to make money. That is why the measurements defining investment efficiency should have a financial character. Throughput Accounting suggests that making this kind of decisions should be based on the three aforementioned measurements of effectiveness [3]:

- Throughput (T),
- Investment (I),
- Operating expenses (OE).

When planning any investment or before implementing any change we should check, with the help of effectiveness measurements, whether these planned actions will make us closer to the main aim. An ideal situation is when throughput increases and investment and operating expenses decrease. Nevertheless, it is possible to accept a decision which changes positively only two measurements. Still, it needs to be borne in mind that the most important measurement in TA is production and that is why it is advised to make decisions which influence the increase of production and a decrease in at least one of the remaining measurements.

Production manager’s suggestion. Accepting this suggestion we will not achieve bigger production as the pace of production will not change so it will still be possible to produce 40 cog wheels in an hour (see Fig. 2). When using the algorithm, on the basis of only the analysis of production, the suggestion should be turned down because of its inefficiency.

Manager’s assistant’s suggestion. Accepting assistant’s suggestion we will increase production as increasing the efficiency of operation 3 will make it possible to produce one piece an hour more. Achieving bigger production, in comparison to the present state of things, allows for implementing next steps of the algorithm which should help to make a good decision. Table 2 presents comparison of the present profit with the profit possible to achieve after implementing optimisation of a production process.
We have 176 hours a month (8 hours multiplied by 22 days) at our disposal, which means that thanks to introducing the changes suggested by the assistant we can produce and sell 176 cog wheels more than before. If we do not change the price of 50 Euros, it will give us an increase in profits by 8800 Euros a month. Production will increase by 6160 Euros, operating expenses by 166.67 Euros (10000 zł/5 years/12 months) and investment by 10 000 Euros. The profit gained thanks to the changes suggested by the assistant has been calculated according to the equation (3):

\[ N P = T - OE = 6160 - 166.67 = 5993.33 \text{€}. \]

After a year it is possible to generate a profit of 71 919.95 Euros (5 993.33 × 12 months). A fundamental phase of the algorithm is earmarking ROI ratio. Consequently, the analysed suggestion gives the following return from the investment (on a yearly basis) (4):

\[ ROI = \frac{NP}{T} = \frac{71919.96}{10000} = 7.19. \]

Such a high ROI ratio prompts the company to accept the project suggested by manager’s assistant. In a year a company will generate more than 7 times as big profit as compared to operating expenses.

A production system should be seen as a chain of intertwined operations. The basis of improving any system is finding an element or a process which limits that system. The idea of a bottleneck in a production process is shown in Fig. 5.

The element which limits capabilities of a production line is the post or operation which has the lowest efficiency and, in consequence, determines the efficiency of the whole line. The main characteristic of a bottleneck in a production process is exploiting the capabilities of this resource in 100% [13]. This factor makes us realise the importance of the problem of existing bottlenecks in production. It needs to be pointed out that exploiting production capabilities of a given work stand in 100% entails an enormous threat to the effectiveness of production processes. A work stand which is a bottleneck is not only characterised by the highest level of exploitation, which entails a high risk of malfunction, but it is also the main factor affecting the term of realising the whole production process. A bottleneck is a resource which does not allow catching up with orders which are back or delayed. It needs to be concluded that an hour which is lost on a bottleneck is a lost hour for the whole production process while an hour gained out of a bottleneck does not have any substantial meaning for the time of the whole production process [14]. Several techniques for dealing with the bottleneck are [15]:

- increasing capacity of the constraint; this may require a capital investment or more people and may take a while to implement,
- ensuring that well-trained and cross-trained employees are available to ensure full operation and maintenance of work center causing the constraint,
- developing alternative routing, processing procedures or subcontractors,
- moving inspections and tests to a position just before the bottleneck; this approach has the advantage of rejecting any potential defects before they enter bottleneck,
- scheduling throughput to match the capacity of the bottleneck; this may mean scheduling less work at the work centers supplying the bottleneck.

The discussed problem of production constraints explains conforming production schedule to the schedule of ceaseless work of a resource called a bottleneck. The bottleneck presented in Figure 5 shows a situation when two production lines are using one work stand, which causes going beyond the level of exploiting production capabilities [16]. Of course, it is not the only example of constraints occurring in a production process. Production constraints can be caused by many reasons such as lack of machines,
lack of production space, lack of qualified workers, disturbed materials availability or even lack of financial means [17]. Therefore, if we want to increase the efficiency of a production system, we need to increase the efficiency of a bottleneck as it is the bottleneck that determines the size of sales, which is the aim of production system’s existence.

In the discussed example the size of sales is determined by operation no 3 as it is the operation with the lowest efficiency. Implementing the changes suggested by the production manager would be beneficial from the point of view of individual expenses or local efficiency. However, in consequence, accepting this idea would not bring the company profits. On the contrary, it would only bring loss. The company would not only unnecessarily invest 5000 Euros, but also, if it produced using maximum productive power, it would constantly enlarge the reserves of work in progress, which is disadvantageous for a company.

Conclusions

The presented analysis reveals that employing cost count to analyse investment efficiency gives much worse results than using the measurements of throughput accounting and the algorithm suggested by the authors. It can be even stated that cost count has lost its currency as it is based on the assumption that most expenses are directly connected with the size of production [4]. It was veritable some time in the past when labour’s proportion in the all-in expenses was substantial. Due to common automation of processes and employment of new technologies, labour’s proportion in all-in expenses of a company has fallen drastically. In consequence, the measurements used in a cost count do not give correct answers to the question about the commercial viability of a given investment.

The measurements of throughput accounting used in the algorithm are based on very logical rules. An analysis of investment should by begun by pinpointing the aim of company’s existence. As it has been mentioned earlier, the aim of a productive company is making money. That is why the measurements used for assessing investment should answer the question of whether we are going to make more money due to implementing the suggested change. An investment can be accepted if the answer to at least one of the following questions is “yes”:

- Will this investment bring a decrease in all-in expenses?
- Will this investment bring an increase in proceeds?

These questions can be simplified to form the algorithm presented in this article. Using this algorithm will make the calculations easier, which will make the process of decision-making shorter. It is enough if we identify the system’s constraint, in other words the resource which is the weakest and, because of that, it determines the size of production. If a company’s aim is to make money and we know which resource limits us the most in gaining this aim, it is enough if we analyse the efficiency of an investment and in this way we will check how this investment will influence productive capabilities of a bottleneck. If implementing suggested changes increases the size of production, then the investment can be accepted for a further analysis. If it does not change the size of production, then it should be turned down. The only effect of accepting an investment which does not increase the productive capabilities of a resource which is a system’s constraint is the expenses spent on the investment. The global size of production is determined by a system’s constraint and that is why hastening processes which are not a constraint does not give any financial benefits to a company.

There is one more important factor which needs to be taken into consideration when choosing the measurements, namely one needs to consider whether the constraint is internal or external. In the analysed example it has been underlined from the very beginning that the demand for the goods produced is much bigger than a company’s productive capabilities. It means that a system’s constraint which does not allow a company to make more money is inside the company. The presented algorithm can be used only in the case when we deal with an internal constraint. If the constraint would be an external one, for example the demand would be lower than a company’s productive capabilities, then we should employ different measurements such as, for example production/production unit [18]. However, we need to remember that throughput accounting, similarly to TOC concept, is rarely used in practice due to its revolutionary assumptions. That is why the suggested by the authors algorithm can make using this concept much easier, which would obviously influence its popularity. However, the literature of the subject matter [3, 19, 20] reveals studies which in contrast to one another show differences between ‘the World of Expenses’ and ‘the World of Production’. This fact makes it difficult to carry a research which would unanimously affirm the superiority of throughput accounting over cost count.

References

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