

Implementation of Theory of Constraints (TOC) in a Manufacturing Plant

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Abstract

Theory of constraints is an overall management philosophy aimed at improving the performance of firms. Theory of constraints identifies constraints or bottlenecks in a production system and suggests a methodology to systematically manage the bottleneck and then eliminate it. This study is conducted in the supply chain department of a manufacturing plant to understand the benefits of implementation of Theory of Constraints. A survey using a questionnaire is carried out among the employees of the department to get the results. It is seen from the study that implementation of Theory of constraints has resulted in better profits, better coordination among various departments, eased out work pressure among employees and reduction in inventory levels.

Keywords: *Theory of Constraints (TOC), Manufacturing, Bottlenecks, Drum-buffer-rope*

1. Introduction

Dr. Eliyahu Goldratt introduced Theory of Constraints (TOC) as an overall management philosophy in his 1984 book titled, "The Goal". TOC is seen as a philosophy or a management approach that is geared to help organizations continually achieve its goal. According to TOC, the goal of any organization is to make profits now and, in the future (Goldratt & Fox, 1993). Organizations or units in organization will always have a constraint or a bottleneck which will restrict or limit the system's ability to achieve the goal of profit maximization. The theory of constraints focuses on the biggest constraint and uses an approach where all the other processes are made to revolve around this constraint. It is also a continuous management system where the constraints are improved upon or strengthened which will lead to a redefined process with another constraint becoming a bottleneck. Thus, TOC is a useful and powerful approach in manufacturing organizations for continuous improvement and profit

maximization (Pegels & Watrous, 2005). TOC has also become a problem structuring and solving methodology which changes the way of thinking of managers. (Şimşit, 2014).

TOC approach believes that every complex system, like a manufacturing processes which consists of multiple linked activities, has a weak link, which is a constraint. As the saying goes, "a chain is as strong as its weakest link", and if force is applied to the chain at an increasing rate, it would eventually break at its weakest link. The processes, as well as, organizations can struggle and break in its effort in achieving the goal if this weak link is not identified and strengthened.

From an organization's perspective, the bottleneck or the constraint can be from any of the functional areas like marketing, finance, procurement, production, or strategic planning and TOC is found to be beneficial in all these areas. More specifically, constraint can be in the form of physical resource like inadequate supply of raw material, lack of equipment capacity, or the constraint can be behavioral or policy related which can limit the production capabilities [Bernardi & Pires (2010), Mabin & Balderstone (2003)]. This study is done in a bicycle assembling plant where TOC is implemented in the supply chain department of the plant.

2. Literature Review

TOC has been implemented by many organizations, especially manufacturing organizations and has benefitted from this approach. It is found from literature that TOC has been beneficial in many areas like services, marketing, projects, and process industries (Tulasi & Rao, 2012). Implementation of TOC helps managers to identify improvement projects which has greater impact on the bottom line. The approach of TOC is to continuously look for constraints as these change with changes in environmental conditions (Ehie & Sheu, 2005). It is

found that TOC principles help manufacturers including small manufacturers to look at innovative ways of increasing throughput and thus maximizing profits (Kohli & Gupta, 2010).

TOC as a theory provides approaches and can serve as a unifying theory for to managers which can help in avoiding pitfalls by improving coordination among various departments (Gupta, M. C., & Boyd, L. H., 2008). Application of TOC helps in improved inventory management performance in production plants as TOC helps in focusing on the constraint thus eliminating conflicting requirements of various departments (Chou, Lu, & Tang, 2012). It is found that TOC implementation results in reduced inventory levels, reduced transportation lead times and costs, improved forecasting accuracy leading to better customer service levels (Wu, et.al. 2013). It is found that proper implementation of TOC results in positive, observable outcomes of increased throughput, reduced inventory levels, and reduced operation expenses. (Inman, Sale & Green Jr, 2009). TOC also helps in improving production efficiency (Bai et. al., 2018).

Today companies are not operating in isolation, but they are interlinked with other players, suppliers as well as distributors, of their supply chain. Supply chain collaboration becomes an important factor in this scenario the success of the firm. Hence, it is towards important to understand the constraints existing in the supply chain. Theory of constraints can be applied to understand the constraints in the supply chain and helps in gaining benefits of supply chain collaboration (Simatupang, Wright, & Sridharan, 2004).

Theory of constraints is also seen as an approach which can be applied along with other improvement approaches like lean manufacturing and quality management approaches of TQM and Six Sigma. Alvarez, Aldas, & John (2017) states that by applying TOC along with lean management resulted in reduction in non-value added activities and inventory.

3. TOC in Procurement and Inbound Logistics

Procurement system which is a part of the supply chain of the company plays a crucial role in making sure that required components and raw materials are available at the right time at the plant so that the production is not affected. The task of a procurement manager is complex as different components will have different demand patterns, different suppliers, and different lead times. The manager most often will have to take decisions very quickly and a proper

plan of action and proper system is essential. Application of TOC is helpful in this functional area as TOC helps to identify the bottlenecks and helps manager in taking right actions for those critical items to be procured.

In a supply chain for smoothened production, the focus should be on making sure that the entire chain of suppliers is aligned and are as strong as one another. One weak supplier can become a bottleneck and can disrupt the whole chain and will lead to delayed delivery to the end consumer. Inappropriate information network also can create havoc in the supply chain. For an efficient responsive supply chain, seamless flow of information among the various links is essential. Delays in order requests between different members of the chain, internally and externally can affect supply chain planning.

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4. Steps in implementing TOC

Goldratt recommends a five-step process for the implementation of TOC in organizations.

Step 1: Identify the system constraint

In implementation of TOC, first step is to identify the constraint in the system. For e.g., in the purchasing department, capacity of the supplier can become a constraint. If you are relying on one supplier and he is having difficulties in meeting demands of his various customers including you, this can become a constraint for you and delays in delivery of items can happen.

Step 2: Decide how to exploit the constraint

Once the constraint is identified, next step for the organization is to "exploit" the constraint by utilizing every bit of the constraining component without committing to potentially expensive changes and/or upgrades. Efforts may be taken to make sure that attention is focused on constrained process or resource and it is fully utilized. In the case of the example cited above, the purchasing department should have a very clear knowledge about the supplier capacity and their delivery schedules.

Step 3: Subordinate everything else to the constraint

The next step is to subordinate all other activities of your firm to the constrained resource or process or in other words, organizations should adjust the rest of the system to enable the constraint to operate at maximum effectiveness. For the example used, your entire production schedule should be aligned with the capacity of the supplier.

Step 4: Elevate the constraint

The next step is to take steps to eliminate the constraint if the above steps were not able to make that process/resource a non-constraint. When supplier's capacity was continuing as a constraint, one can try eliminate it by identifying alternate sources of suppliers to reduce the reliance on one supplier.

Step 5: Go back to Step 1

Last step is to go back to identify new constraint as the earlier constraint would have been eliminated and go through the cycle of implementation once again.

5. Drum-Buffer-Rope Theory

Goldratt uses a methodology called Drum-Buffer-Rope methodology for implementation of TOC. It is named after the three essential elements of the solution; the drum or constraints or weakest link, the buffer or material release duration, and the rope or release timing. The aim of the solution is to protect the weakest link in the system, and therefore the system as a whole, against process dependency and variation and thus maximize the system overall effectiveness. The outcome is a robust and dependable process that will allow us to produce more with less inventory, less defects, and better on-time delivery always.

- **Drum** is the constraint and sets the pace of production flow. In the example used, drum is the supplier's production capacity which will lead the flow across the supply chain.
- **Buffer** is the level of inventory needed to maintain consistent production; this is the buffer inventory held by the supplier in order to protect the downstream supply chain from disruptions
- **Rope** is a signal generated from the buffer to release material. This is the link between supplier's capacity and the sales at the downstream end of the supply chain.

6. Significance of the study

The theory of constraints as a theory is being implemented in various manufacturing firms and is an evolving methodology for continuous improvement. The theory of constraints maintains that a few constraints keep complex processes such as business functions from reaching optimized performance. Managers have to identify the constraints that affect their business and work to mitigate their impact and remove them. Managers can reduce the effects of constraints as they identify theme and use the theory of constraints to guide them in continuously improving company performance.

It is important that these methodologies are implemented and its impact on other parameters like profits and performance is studied so that the benefits are understood by business managers. For a manufacturing firm, today there are a number of practices available such as lean manufacturing, total quality management, Six Sigma, total productive maintenance etc. which are all approaches to improve the performance of a manufacturing firm. This study looks to understand the benefits of implementation of theory of constraints.

7. Objectives of the study

The study is carried out to understand the process of implementation of Theory of Constraints in the supply chain department of a manufacturing firm. The objectives of the study are:

- To study the constraints faced in supply chain of the firm
- To study the benefits of implementation of Theory of Constraints in the supply chain department of the firm

8. Manufacturing process

The process involves making of the frame and fork assembly where the steel tubes of required shapes are welded together, tested for alignment and strength, and painted as per the design specifications. Then, logos, and stickers are fixed on to the frame. Then, the subassemblies of chain wheel crank assembly, handle bar assembly, gear teeth chain assembly, front and rear brake assembly, front and rear cable assembly, front and rear wheel assemblies are assembled and tested. The items are tagged properly and the final stage is packaging where the assemblies along with pedals, side stand kits, screws, nuts and bolts are packed.

In the manufacturing plant under study, a bicycle is assembled using 18 different components or

subassemblies. These materials are received from different suppliers spread across the country.

9. Methodology of the study

A survey using a questionnaire is carried out among the employees of the supply chain department to study the challenges or constraints faced in the department and benefits of implementing TOC in the department. Sample size used for the study is 30 employees from a population of 42 employees in the department. Sample was selected through convenience sampling.

10. Results

Table 1: Mean score on Challenges / Constraints in Supply Chain

Sl. No.	Sources	Mean
1	Raw material shortage	3.7
2	Equipment shortage	3.03
3	Labour shortage	3.03
4	Lack of space	2.73

It can be seen from the table that facing raw material shortage is one of the most important constraints faced. This results in added pressure on the employees working and on the production process. It is understood that there are two reasons for the shortage of raw materials faced.

One reason is that the plant procures raw materials from various parts of the country and a majority of the components come from northern India whereas the plant is situated in the southern India. This results in delays in delivery. Any urgent deliveries cannot be met because of the distance involved. This also has resulted in lack of proper communication between the plant and the suppliers. The situation of raw material shortage becomes critical especially during the peak season when the demand is high. In order to overcome these shortages and to have continuous monitoring of the raw material inventory a colour coded system is used in the department.

Inventory is classified as follows and colours are used to indicate the criticality of situation.

Buffer	90% above	→ White (crime)
	90% to 60%	→ Green (Ok)
	60% to 30%	→ Yellow (Ideal)
	30% to 1%	→ Red (danger)
	at 0%	→ Black (highly critical)

Table 2: Mean Score on benefits of TOC implementation

Sl. No	Sources	Mean
1	TOC helps to increase the profit	4.1
2	Positive feedback from Market	3.7
3	Procurement Policies help the company to get good quality raw material	3.7
4	Inventory storage help the firm from sudden fluctuation in cost	3.7
5	Ease out working pressure	3.6
6	TOC help to take right decision right time	3.6
7	TOC act better than the old system	3.5
8	TOC helps to enhance customer response time	3.5
9	TOC helps to increase coordination between departments	3.4
10	Increase the sales drastically	3.3
11	Reduction of inventory	3.1
12	TOC help to solve the bottle neck problem in raw material procurement	3.1
13	TOC for the supplier helps to get the material in right time	3.1
14	TOC is a tool for modern era of business	3.0
15	TOC helps to reduce costs associated with held finished goods inventories	3.0

Respondents are of the opinion that implementation of TOC has helped in increasing the profits of the firm and has resulted in getting positive impact from the market. This has also helped in getting better quality raw materials. Implementation of Theory of Constraints has helped the employees to reduce their work pressure as critical processes and resources are identified and hence problems can be understood earlier and is addressed

6. Conclusion

The study is carried out in a bicycle manufacturing plant to understand the implementation of TOC in the procurement and inbound logistics of the plant. TOC offers advantages to manufacturing organizations in streamlining production. It is found that implementation of TOC offers a number of benefits including reduced inventory levels, solving bottlenecks in raw material procurement, improved coordination between various departments. This also helps in better response time for meeting customer demands, which leads to increased sales and better profits for the firm. The implementation and practice

of TOC also helps in reduced work pressure among employees and management.

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