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## Theory of Constraints: A Literature Review

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### Abstract

Theory of Constraints (TOC) is a management philosophy which is focused on the weakest ring(s) in the chain to improve the performance of systems. Companies, whether they are in the production or service sector should be more focused on understanding their own structure in terms of processes to survive in a global competition. In this situation, TOC becomes an important problem structuring and solving methodology which changes the way of thinking of managers. Since the TOC first put forth by Goldratt (1984) in his novel *The Goal*, the theory has drawn wide attention from practitioners and academic researchers. This study provides a review of the TOC evolution literature by its five era; the optimized product technology era, the goal era, the haystack syndrome era, the it's not luck era and the critical chain era. Our search at historical background and basic concepts of TOC aims to see how this philosophy evolves through time and how the main point of TOC researches changes.

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*Keywords:* Theory of constraints, Optimized production technology, The goal, The haystack syndrome, Critical chain project management

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### 1. Introduction

Nowadays, companies struggle to survive in a global competition. Every company tries to find the best philosophy which is suitable with their strategy to gain any and every advantage among their rivals. Companies should be more focused on understanding their own structure in terms of processes whether they are in the production or service sector. In this situation, Theory of Constraints (TOC) becomes an important theory which focuses on the weakest ring(s) in the chain. TOC views processes as they are rings of the same chain instead of thinking they are independent from each other. At the same time, theory focuses on the weakest points which are bottlenecks for the entire company and try to determine the relationship of these bottlenecks. Therefore, this integrated management philosophy changes the way of thinking of managers and become an important tool for solving root problems.

Originally TOC is used to plan the production process and allocate resources but its content is improved day by day as the technology evolves and competition between rival companies increases in business world. Nowadays it can be used a kind of management philosophy and can be integrated with cost accounting system. It is not of importance

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which sector your company belongs because TOC is actually based on system improvement. Since 30 years, TOC is successfully implemented by almost every sector and with almost every size of companies.

TOC is based on the idea that every system has at least one bottleneck which can be defined as any kind of situation that impedes the system to reach high performance level in terms of its purposes (Goldratt, 1990). In literature there are several studies to understand this management philosophy in detail. In their study Watson et. al. (2007) stated that to better understand the historical evaluation of TOC it can be useful to separate its evaluation into five eras; (i)The optimized product technology era, (ii)The goal era, (iii)The haystack syndrome era, (iv) The it's not luck era and (v) The critical chain era (Watson et.al., 2007). This classification is useful to see how this philosophy evolves through time and how the main point of TOC researches evolves.

In literature initial studies generally focused on optimized production technology which is improved by Goldratt in 1980s. On the other hand when the book named "The Goal" published in 1984, studies about TOC were rapidly increased and researchers started focus on the architecture of drum-buffer-rope. After the importance of TOC is realized by academicians and managers, studies started to focus on TOC measures, thinking processes which is one of the most important tool of TOC and project management and etc. Recently, after almost 30 years TOC is still one of the greatest strategies for companies.

## 2. Literature Review

Theory of constraints has a wide range of implementation scale. Theory can be applied in production, logistics, supply chain, distribution, project management, accounting, research and development, sales and marketing and so on. As the main idea is that every system has at least one weakest point, in literature there are lots of studies which have different concentration areas and reveals different issues of TOC. Therefore, there are several definitions for TOC. On the other, there is a common point which is defined in almost every study, constraint. The main aim of every company is increasing the profit. According to this point of view, constraints are main obstacles at achieving companies' aims. In other words, everything which exists in the road of having more profit is considered as a constraint. So, if companies can handle constraints in their system and manage these constraints, they would have a continuous improvement management system thus they could achieve higher profits. This simple logic leads to many questions and for this reason alone pushes researchers to investigate every aspect of TOC. In this study, to better understand the evaluation of TOC, Watson et al.'s five era structure is used. Although these five eras based on the names of Goldratt's books, it is most useful to see the basic principles of TOC and analyze the development process.

### 2.1. *The Optimized Production Technology Era-(1979-1984)*

In 1979 when Goldratt introduced its solution called "Optimized Production Technology (OPT)" to increase the output of a firm which could not satisfy the demand because of resource constraints, it drew too much attention in the USA and immediately it is started to be used in companies with utmost urgency. On the other hand, the logic could not decode clearly for that reason academicians did not pay enough attention and continued to use traditional approaches.

In literature there are several studies about OPT although there was not considerable attention about OPT at the beginning. OPT was introduced at 1979 but actually its importance realized after TOC was introduced and then they spread together all around the world. In 1983 Jacobs searched how OPT can be used in scheduling and production planning, Fox (1984) investigated main bottlenecks on the factory floor and tried to explain basics of OPT. Harrison (1995) tried to explain concept of OPT by focusing on the goal of the manufacturing organization, Aggarwal (1985) stated that choosing a system takes time and sometimes implementation can cost millions of dollars so in the study he benchmarked MRP, JIT, OPT and FMS. The other study which benchmarks MRP, JIT and OPT belongs to Gelders and Waasenhove (1985). They discussed these inventory control systems according to capacity constraints. In the study main differences were determined and they tried to explain how these techniques could complement each other. Ronen and Starr (1990) stated that drum-buffer-rope (DBR) concept can be used in OPT.

## 2.2. *The Goal Era-(1984-1990)*

OPT was a successful software program but the main problem why it could not gain enough attention was that the lack of understanding with regard to how OPT schedules were produced. Therefore, Goldratt and Cox (1984) published a book named “The Goal” as a marketing tool to educate both managers and workers about OPT. Although The Goal was written largely to educate workers at facilities using OPT, it became a best seller business novel which describes number of heuristics and techniques that have become the foundation for TOC (Watson et. al., 2007).

The Goal described Alex Rogo’s story who is a manager at UniCo factory. There was an order which was delayed for 7 weeks and if core problems were not to be solved, factory would be shut down because of huge costs of order delays. After careful researches, Alex found that there were two bottlenecks and he managed to save his plant with the help of his mentor Jonah.

The Goal explains the Five Focusing Steps (5FS). The working process of implementing TOC concepts consists of 5FS which is called Process of On-Going Improvement. The steps are (Goldratt and Cox, 1984; Goldratt and Cox, 1992); (i) identify the system’s constraint, (ii) decide how to exploit the system’s constraint, (iii) subordinate everything else to the above decision, (iv) elevate the system’s constraint and (v) if in any of the previous steps a constraint is broken, go back to step 1. Ronen and Spector (1992) extended the process of continuous improvement by adding two preliminary steps so redefined it as a seven step method, (i) define the system’s goal and (ii) determine the global performance measures.

As it can be seen, TOC focus on continuous improvement philosophy by dealing with constraints. According to Goldratt (1990), while dealing with constraints three basic questions about change are required to be answered; (i) what to change?, (ii) what to change to\* and (iii) how to cause change? Goldratt’s Theory of Constraints is essentially about change and the Five Focusing Steps are directly concerned with these three basic questions about change that every manager needs to know. To determine what to change is looking for constraints; to determine what to change to, defining how to exploit constraint and subordinate other operations; to determine how to cause change is the elevate step (Dettmer, 1997).

Scheinkopf (1999) defined these as prerequisite steps so the Process of On-Going Improvement is an amalgamation of the Five Focusing Steps and the two prerequisites of its for implementation (Watson et. al., 2007). As the first prerequisite of process, the purpose of the system has to be defined. For the second prerequisite, measures of performance which is the actual throughput of the system need to be proper (Coman and Ronen, 1994). Goldratt says the goal of an organization is to make more money now and in the future. In order to make money, an operating system should increase its throughput and reduce its inventory and operating expenses (Goldratt and Cox, 1992). So, performance measurements in a system are throughput, inventory and operating expenses. The performance of any system is limited by the rate of throughput at the constraint; therefore identifying the system’s constraint as the weakest link of the chain is the first step of on-going improvement process. The second step, exploiting a constraint is getting highest possible output at itself with eliminating the limitations on that constraint. To support the decision made in second step, whole system is subordinated to the constraint as the third step. The fourth step is increasing the capacity of the constraint due to get efficient throughput. Hereby, the improvement cycle repeats itself when another operation becomes the system constraint.

## 2.3. *The Haystack Syndrome Era-(1990-1994)*

TOC is an effective approach but need to be endorsed with performance measurement system. The underlying reason is that every company wants to measure the effect of improvements on their system. This main idea leads to the development of a process-focused performance measurement system. This system focuses the organization on actions that improve overall financial performance. In literature this framework called “Throughput Accounting”. According to TOC there are financial and operational measurements. Financial performance measures are net profit, return on investment and cash flow which are global performance measurements. TOC uses this measurement system but states that they are not enough in the subsystem level. So there must be operational measurements as well which are, throughput, inventory and operating expense.

In 1998 Lockamy and Spencer stated that “TOC” measurement system can be used in conjunction with existing systems, provided all measures are consistent with the organization’s goals. But, an additional system will be required to provide regulated external information.” Fu (2000) benchmarked TOC and activity-based costing system and Schragenheim (2000) tried to explain basics of TOC accounting. Kaygusuz (2006) examined the sales decisions with using TOC. In 2008 Utku and Ersoy investigated throughput accounting, and similarities and differences have been exposed by comparing the throughput accounting with conventional cost accounting methods, activity based costing and strategic cost methods. Demircioğlu et al.’s (2010) study showed the relationship between theory of constraints, absorption-variable costing and activity based costing.

#### *2.4. The It’s not Luck Era-(1994-1997)*

In 1994 Goldratt published his new book named “It’s not Luck” which presents roadmap to discover solutions for complex processes. This solution called “Thinking Processes” and while The Goal clearly defines management policies and drum buffer rope system, this new tool focuses on root problems and provide alternate solutions.

A logical approach known as Thinking Processes (TPs) of TOC has evolved to address the basic questions (Dettmer, 1997; Kendall 1998). In much the same way as the Five Focusing Steps focus on the constraint, the TPs focus on the factors that are currently preventing the system from achieving its goals (Tulasi and Rao, 2012). The TPs provide five logic tools to provide a rigorous and systematic means to address identification and resolution of unstructured business problems related to management (Watson et al., 2007). The TPs tools have two different types of logic: cause-effect logic which is used in the Current Reality Tree (CRT), Future Reality Tree (FRT), Transition Tree (TT) and necessary condition logic which is used in Evaporating Cloud (EC), Prerequisite Tree (PRT).

The five stages of the TPs starts with the first decision question what needs to be changed and CRT is used to identify the weakest link of chain which is system’s constraint. CRT is a logical structure that depicts the state of reality as it currently exists in a given system (Rahman, 2002). Once the core problem has been identified, in response to second question the tools EC and FRT are used. EC resolves hidden conflicts that usually perpetuate chronic problems (Dettmer, 1997). The construction of the FRT can be viewed as “a what-if exercise”, to identify the actions and conditions will be necessary to bring about the desirable effects or change (Davies et al., 2005). Once the third stage of the TPs identified the question what to change to, the remaining question deals with how organizations should implements the solutions to achieve the change. PRT and TT are typically used to develop the necessarily comprehensive implementation (Cox et al., 2005). PRT identifies obstacles to implementation of new ideas and finally TT creates an implementation plan step by step.

In literature there are too much researches, case studies, theses, and company implementations about TP. Many of them benchmark TOC and other popular management philosophies and when doing these benchmarking they are using TP in order to see the effects of TOC. Especially in service sector companies TP is commonly used for TOC implementation. In another view today many academician analyze TP and try to formulate strategies. So they are creating strategy and tactics tree in addition to existing TP trees.

### **3. Conclusion**

Goldratt says the goal of an organization is to make more money now and in the future. In order to make money, throughput of an operating system should be increased while its inventory and operating expenses are being reduced. Therefore the performance of any system is limited by the rate of throughput at the system’s constraint; identifying the system’s constraint as the weakest link of the chain and eliminating it is the main idea behind the TOC. As can be seen it actually focuses on continuous system improvement by dealing with constraints, the theory can be implemented to almost every sector and almost every size of companies. Since it has been first put forward by Eliyahu Goldratt in the early 1980s, TOC has found acceptance as a management philosophy and has drawn wide attention from practitioners and academic researchers. In literature it is possible to find several studies to understand this in detail. With the motivation of searching historical background of this management philosophy and basic concepts of TOC, we had a literature review in this study and aimed to see how this philosophy evolves through time with regarding benefits and

the grounds it creates for further studies. In addition to theoretical search we aimed to highlight important findings on practice of TOC and to mark gaps in application fields through that extensive search of literature.

We examined the historical evaluation of TOC in five eras as separated in literature which are also the names of Goldratt's books; (i) The optimized product technology era, (ii) The goal era, (iii) The haystack syndrome era, (iv) The it's not luck era and (v) The critical chain era. By the 1980s general focus was on Optimized Production Technology; concurrently with the publication of "The Goal" in 1984, researches were begun to focus on the architecture of drum-buffer-rope. Along with the importance of TOC was realized by academicians and managers, studies have started to shift the weight to the TOC measures, Thinking Process which is one of the important tool of TOC, the Five Focusing Steps which is continuous improvement technique and Critical Chain Project Management. TOC has now evolved into a management theory in terms of both methodology and fields of applications whereas it was a manufacturing method initially. After almost 30 years TOC is still one of the greatest strategies for companies.

Based on this survey it can be seen that the newer applications of TOC involve fairly use of the Thinking Processes, especially in service sector it is commonly used for TOC implementations. Critical chain project management applications appear to be a growing area. Although the achievement in real life applications of critical chain project management is significantly impressive, still there isn't enough study about project management. The present study shows that some important issues in the Project Management are not adequately emphasized.

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