Comparing JIT and TOC

A comparison regarding methodology and performance.

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Abstract: During the past two decades, development in the manufacturing industry had led to an increased competition between the companies in the market. Focus on improvements and methods for production planning and control have become essential for the companies to prioritize, in order to improve their processes and, consequently, remain competitive and sustainable. Traditional methods have been more and more replaced by more modern and competitive approaches, such as Just- In- Time (JIT) and Theory of Constrains (TOC). During time, an extensive number of studies and researches on the philosophies, regarding both methodology and performance, have been conducted, with the objective to provide an answer to the question if there is one method that is more rewarding. But, does an unambiguous answer to this matter exist or is the subject in question, in fact much more complicated than that? This paper attempts to answer this questions providing a literature review on the journal articles concerning the issue.

Keywords: JIT, TOC, Supply Chain Management, Inventory Management, Production Planning, DBR, Kanban

1. Introduction

Development of the manufacturing industry over the last two decades has led to increased competition between the companies in the industry (UNIDO, 2013). This, in turn, has led to strategic and structural changes within the business. It has become more essential for the companies to prioritize concepts such as supply chain management and production planning and control, in order to improve their

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processes and as a result, also remain competitive and sustainable (Gupta and Snyder, 2009).

During recent decades, traditional methods for planning and control of production systems have been replaced gradually with other philosophies such as Just- In- Time (JIT) and the Theory of Constraints (TOC). The strategic changes are actions taken, in order to achieve competitive superiority (Lea and Min, 2003).

The manufacturing philosophies JIT and TOC and their methods and tools have been studied and applied by companies worldwide. However, some questions and matters still needs to be answered and clarified. Which of the two approaches is the most advantageous? Can this question be answered unambiguously, or is the subject in question in fact more complicated than that? A large number of literature and scientific articles discuss the subject and attempt to answer these questions, comparing the two philosophies and their ability to improve and make the production process more efficient.

The aim of this essay is to examine existing literature that debate the issue. The first part of the study provides a short introduction of the two philosophies and their separated methods. The second section of the review is a comparison divided in two parts. Firstly, an assessment is done on research results regarding the methodologies of TOC and JIT, in theory. The other part concerns literature related to the actual effect of the methods, when applied in practice. Thereafter, two tables sum up the comparison, providing a brief summary of the results and the literature reviewed. Finally, the concluding paragraphs sums up the paper by providing a brief discussion and conclusion with a summary of the most important results.

2 Research methodology

This paper is a literature review comparing the production philosophies JIT and TOC. Literature and scientific papers that highlights the philosophies and their particular methods were studied, as well as articles discussing the differences and the similarities between the two approaches. Additionally, articles comparing the performance of the two philosophies were reviewed.

Initially an article by Gupta and Snyder (2009), where TOC is compared with both MRP and JIT, was contemplated. With their research as starting point, the subject was explored further by studying the references used. Furthermore, adding other articles and assessments regarding the issue provided a more inclusive review.

There is a time difference of twenty years between the oldest and the most recent publicised article assessed in the review. The majority of the articles found, regarding the issue, have been written in the 90s when the philosophies and their methods still were rather new and an unexplored territory. Still, articles from the 90s are to be considered as actual and relevant since they concern the fundamental ideas of the philosophies.

The databases used, to find articles regarding the subject, were Discovery, IEEE Xplore, Emerald and Google Scholar. The majority of the scientific sources used in this paper is articles from the journal, *International Journal of Production Research.* Keyword used to search for relevant sources were: *JIT, TOC, Supply Chain Management, Inventory Management, Production Planning, DBR and Kanban.*

The review was narrowed, due to time and length restrictions, therefore the paper present merely a short introduction to the philosophies, despite the extensive existing literature and textbooks dealing exclusively with the topic. Regarding the comparison of the both philosophies and their methods, a limited amount of articles were reviewed. Hence, this paper provides merely a brief review of the articles concerning the issue. Deeper analysis of calculations or results has not been conducted. As a further delimitation, when comparing the performances between the two approaches, the performance measures considered were mainly output rate, inventory and cycle time.

3 Literature review

3.1 JIT

The abbreviation JIT stands for Just- In- Time, and the management philosophy originates from the Toyota Production System. Other names for JIT are Lean Supply Chains and Zero- Inventory System. (Vrat, 2014)

Vrat (2014, 152) describes JIT as "to produce or supply whatever is needed, wherever needed, and wherever needed just in time with almost no inventories to be maintained." JIT is a typical pull- based philosophy, where the demand of the customer decides the pull for material from one station to another, starting from the last station in the chain. Demands from one station comes, thus, from the preceding station in the production line (Vrat, 2014). The JIT philosophy advocates a balanced line, that is, every station should have the same output capacity (Cook, 1994).

Reducing all sorts of waste[2] is the principal goal of JIT practices (Wu et. al., 2011). Waste is all types of activities and event that does not add value to the production, but still increases the costs or decreases the efficiency (Chakravorty and Atwater, 1996). Excess inventory, for instance, is considered a waste and the elimination of buffers is one of the most characteristic ambition in JIT. The use of a pull system helps avoid build up inventory and by doing this, operational problems can easier be detected and improvements can be implemented (Sale and Inman, 2003).

In addition to the elimination of waste, as stated by Flynn et. al. (1995), practice of the JIT- philosophy include numbers of activities and methods, and one of the most characteristic is the use of the Kanban control system, abbreviated KCS (Takahashi et. al., 2007). The method is aimed to control the material flow in the production (Watson and Patti, 2008). Kanban is cards in Japanese and are used by one station to signal the requirement of material or products to the previous station in the line (Vrat, 2014). Figure 1 represents an illustration of the Kanban buffer system.

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[2]In the Toyota Production System the seven wastes are: overproduction, waiting, incorrect processing, unnecessary movement, unnecessary transportation, excess inventory time and defects. (Liker, 2013)

Another characteristic ambition in JIT is emphasizing continuous improvements, in JIT this is called Kaizen and it is a work method with the aim to achieve constant, small, value added improvements (Liker, 2013).

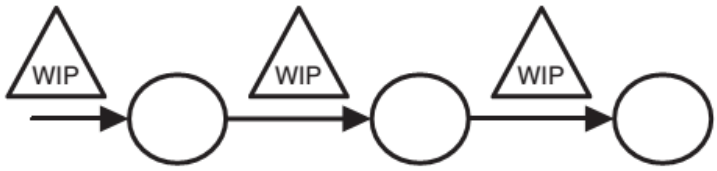

Fig. 1. Kanban production system (Watson and Patti, 2008)

3.2 TOC

The management philosophy Theory of Constraints (TOC) focus on improving the weakest links in a chain in order to increase the efficiency of a system. It considers that the performance of any production system is limited by the weakest link, or the bottleneck[3] and the theory focus on trying to eliminate these constraints. In TOC, the machine or station with the lowest capacity is called the constraint, while the rest of the links in the system goes by the term non- constraints (Şimşit et. al., 2014). While the JIT philosophy emphasize a balanced line, TOC has become a suitable option for companies with unbalanced production lines (Takahashi et. al., 2007).

Analogies can be drawn between the two methods. As in the JIT- philosophy, TOC also uses a pulled- based system. The technique to control the flow of material is called drum- buffer- rope (DBR). In TOC, the constraint is compared to a drum since it is consider to set the pace for the production system. The rope is the link between the bottleneck and the first operation with the purpose to control the production according to the rate of the constraint (Gupta and Snyder, 2009). By using the rope to control the material flow, inventory can be limited in the system and a constant inventory level can be hold in front of the constraint. The third element of the technique is the buffer which is the inventory in the production system. The buffer permits the bottleneck to produce output with less dependency on the input from the previous stations in the line (Watson and Patti, 2008). The drum- buffer- rope is illustrated in figure 2.

Another important cornerstone in TOC is the five focusing steps, a method to achieve continuous improvements (Pretorius, 2014). The five steps include:

1. The first step is to identify the weakest link in the chain, the constraint.

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[3] A bottleneck is a resource, such as a station or a machine in the process chain, whose low capacity limits the productions ability to meet the customer demand (Krajewski et. al. 2010)

2. The second step is to maximize the utilization and productivity of the constraint by using the existing resources more efficiently.
3. The third step is to focus on adjusting the rest of the production chain to the constraint by avoid producing more than the constraint can handle but also provide the constraint with just enough material.
4. As a fourth step, if no further improvements can be implemented by establish step 2 and 3, the capacity of the constraint is elevated by adding physical capacity. Hence investments are required.
5. And as the last, fifth step, if the constraint has been broken, start over again from step 1. Identify a new constraint (Pretorius, 2014).

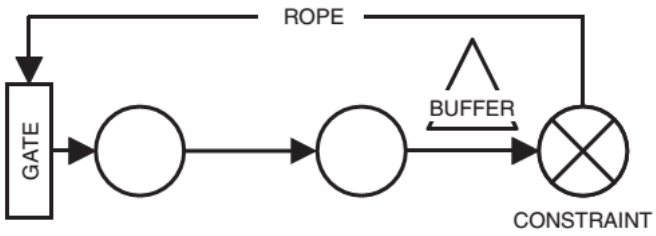

Fig. 2. The Drum- buffer- rope method (Watson and Patti, 2008)

3.3 JIT and TOC compared

There are many similarities as well as differences between JIT and TOC, both in the methodologies and the approaches but also concerning the system performance provided, depending on which philosophy that is applicated.

In this section the comparison is divided into two part, the first part regards the methodologies, in theory and the second paragraph concerns the performance when the philosophies are applied in practice. To sum up the section, table 1 and 2 provide a short summary of the results and the literature compared.

3.3.1 Similarities and differences in the methodologies

The both philosophies, JIT, as well as TOC, puts emphasis on continuous improvements of the production process, right quality and minimum inventories. However TOC concentrates on the activities regarding the weakest link of the system while JIT focuses on the entire production chain (Sale and Inman, 2003).

The two philosophies use methods to facilitate work and provide guidelines in order to continuously make improvements in the production. The method used in TOC is the five focusing steps, providing a structured work approach with the aim to eliminate the constraint of the production chain (Pretorius, 2014). In JIT the method Kaizen is applied in order to constantly make small improvements in the system (Liker, 2013).

Both philosophies use the pull- system, although they use different methods to control the flow of products and material, the DBR in TOC and the KCS in JIC. The main difference between the methods is that Kanban is used as a signal for the requirement of material to the preceding station whereas DBR is used to control the material flow from the first work station (Lea and Min, 2003).

Striving to reduce inventory is a similarity between the both methods since it is considered as waste in JIT as well as in TOC. The goal of JIT is zero inventory, and the elimination of excess buffer in the system is one of the fundamental pillars in JIT (Watson and Patti, 2008). In TOC, inventory is considered a waste only if it is accumulated at a non- constraint. Yet, inventory buffer in front of the bottleneck is considered essential in order to establish an even flow and to reduce dependency of the workstation (Sale and Inman, 2003).

Lea and Min (2003) discuss that both JIT and TOC have the same overall goal: to increase the profit of the company. Despite this shared ambition, the mission differs and the two philosophies take on different perspectives on the matter. JIT for instance argues that by eliminating waste and by ameliorating quality, companies can reduce cost while still prioritizing workers and keeping a sustainable working atmosphere. In TOC, the purpose is to make instant profit and also staying lucrative years to come (Rahman, 1998).

Cook (1994) highlights two major differences between the two approaches. As already mentioned and discussed, the first contrast can be found in the difference between TOC and JIT in whether the plant is accepted to be unbalanced or not. The JIT philosophy favors a balanced plant, consequently, that the output capability of every station is the equal. The TOC philosophy, however, argues that different output capability between the resources is acceptable. Chakravorty and Atwater (1996) debate that the process lines in TOC, in fact strive for unbalance with objective to achieve a process chain with one constraint alone.

Furthermore, the other main difference between the philosophies is stated by Cook (1994) to be the sizes of the batches for transfer and for process. The process batches and transfer batches in JIT are equal, while TOC allows processing and transporting different sizes of batches. This makes it easier to use TOC in batch production. Contradictory, Lea and Min (2003) discuss that neither JIT nor TOC requires equalization between transfer and process batches. Moreover, the authors conclude that another similarity between the two approaches can be detected: both of them recommend small batch sizes (Lea and Min, 2003).

3.3.2 Differences in performance

During time, several studies and research on the philosophies considering their performance have been conducted, with the objective to provide an answer to if there is one method that is more rewarding. The results are ambiguous and and it remains unclear and suggestive which philosophy of the two mentioned, that yields more profit. Apparently, there is not an obvious answer, and the decision to which method to use is not clear. Table 2 provides a summary of the results of the considered sources.

Miltenburg (1997) discusses that obviously, regarding all performance measures, a good implementation of either JIT or TOC is more successful than a poor application of one. The author also debate that, comparing a good implementation of the both philosophies, the use of JIT provides a relatively high output with the lowest level of inventory. Furthermore JIT gives the fastest cycle

time. The use of TOC, on the other hand provides the highest output according to the results of both Miltenburg's (1997) and Cook's (1994) study. Moreover, the results of Sale and Inman's examination (2003) also support these claims. In their study they determine that companies using TOC had considerably higher performance than firms using the JIT philosophy.

The result of the studies by Lea and Min (2003), however, contradict the findings of Miltenburg (1997), Cook (1994) and Sale and Inman (2003). Their results reveal that the JIT philosophy provides higher short- term as well as long-term profitability, better customer service and lower WIP inventory level. This is achieved by using a balanced line and sequencing. This part of their research result correlates with one of the findings of Chakravorty and Atwater (1996); to be more specific, that JIT production achieves the highest output level, given sufficient inventory.

Lea and Min (2003) also state that JIT respond better than TOC to variation and uncertainty in the demand in short range. However, Chakravorty and Atwater (1996) contradict this by putting forward the conclusion that JIT performs best when there are low level of variability in the system and that TOC responds better if the system variability is higher. Plenert (1999), Abuhilal et. al. (2006) and Gupta and Snyder (2009), all support the results stating that JIT is more suitable in repetitive production environments with less amount of variability in demand. Furthermore, the authors determine that the JIT- philosophy is more appropriate when there exist few changes, product options and product mixes in the process.

The result of the research by Watson and Patti (2008) have parallels with the result of authors mentioned above. In their study they compare the ability of DBR and KCS and found that the TOC method, DBR, is more tolerant of system variability than the KCS in JIT. Thus they suggest that TOC outperform JIT in respect of system performance in systems with variation. In the very same research, Watson and Patti (2008) also determine that the application of the Kanban method in JIT requires more inventory than DBR to operate at maximum output. Furthermore they state that due to the lower level of inventory, the DBR systems have a shorter manufacturing lead time than Kanban systems. This argument is confirmed by Sale and Inman (2003) but however, contradicts the findings of Miltenburg (1997), Cook (1994) and Lea and Min (2003) discussed above, that JIT provided the lowest level of inventory.

Table1. Similarities and differences in methodology between JIT and TOC

		Differences	
Aspect	**Similarities**	**JIT**	**TOC**
Overall focus	Continuous improvement, right quality, minimum inventory	Holistic focus on the process	Activities focused on the constraint
System and methods	The use of a pull system and material control methods	Kanban is used to signal requirements of material to the preceding station	Drum- Buffer- Rope is used to control the material flow from the first work station
Inventory	Excess inventory is considered a waste	Zero- inventory is the goal	Inventory buffer in front of the constraints is essential
Overall goal	Increase the profit of the company	Reducing cost by the elimination of waste, quality and respect for humanity	Make money now as well as in the future
Balance in plant		Favor a balanced plant, output capability to be the same at every station	Advocate a unbalanced plant with the aim to achieve a process with only one constraint
Batch size	Small batch sizes Process batches and transfer batches can be of different sizes[4]	Equal process and transfer batches is required	Different sizes of process and transfer batches is allowed

[4] Here the results of Lea and Min (2003) contradict the findings of Cook (1994). Lea and Min state that the batch sizes does not need to be equal in neither of the two philosophies, while Cook (1994) determine that JIT requires equal sized process and transfer batches.

Table2. Differences in performance between JIT and TOC

Reference	JIT	TOC
Cook (1994)	Lowest level of inventory	Highest output. More WIP inventory.
Chakravorty and Atwater (1996)	Achieves the highest output level given sufficient inventory. Perform best with low level of variability in the system.	Best when the system variability is higher.
Miltenburg (1997)	Relatively high output with the lowest level of inventory and fastest cycle time	Highest output
Plenert (1999)	More suitable in repetitive production environments with low product variation	
Lea and Min (2003)	Provide higher short- term as well as long- term profitability, better customer service and lower WIP inventory. Respond better to variation and uncertainty in demand in short range	
Sale and Inman (2003)		Highest performance
Abuhilal et. al. (2006)	More appropriate in processes with few changes, product options and product mixes.	
Watson and Patti (2008)	Higher level of inventory required.	TOC and DBR is more tolerant of system variability. Outperform JIT in system with variation. Lower level of inventory and shorter manufacturing lead time
Gupta and Snyder (2009)	More appropriate in repetitive production environments.	

4. Conclusion

In this paper and assessment, literature and journal articles comparing JIT and TOC, together with scientific articles regarding the theory of the philosophies were studied.

The comparison was divided into two parts, where one part discusses the differences and similarities between the philosophies and their specific methods, concerning the methodology, theoretically. The second part of the comparison, concerns the performance of the two philosophies. The considered body of literature compare the performance of the two philosophies concerning mainly output rate, inventory levels and cycle time. One theme frequently discussed in the articles were also whether JIT or TOC is the most suitable in a process environment with a high level of variability.

In the first part of the literature review, the theoretical part, the results of the different articles were quite unambiguous, hence the comparison were conducted on the philosophies instead of on the sources. In the second section, however, regarding the differences in performance of JIT and TOC, the authors appear to be disunited. The different results were compared and it remains unclear and suggestive if there is one method that is more profitable. Apparently, there is not an obvious answer, and the decision to which method to use is not clear. Where some researches provide a distinct result, some other authors determine exactly the opposite. The majority of the articles considered, however, determine that TOC gives the highest output and is more tolerant of system variability while JIT is more appropriate in repetitive production environments with low level of variability.

5. Discussion

In this review, articles including tests, surveys and simulations with the purpose to compare JIT and TOC regarding the performance were considered. Due to the lack of experience of these kinds of tests and simulations I found it difficult to understand in detail the difference between the tests and their separate results. Therefore it was sometimes complicated to fully understand and analyse the calculations and the results of the tests. This, in turn, could have affected how the results of the articles were interpreted.

It was rather expected that the results of the researches did not provide a clear answer regarding the performance of the philosophies. Obviously the appropriateness of using one method or another depends on the design of the process and type of production. Moreover, the researches considered were conducted on different types of production environments, this could be another explanation to the different results. Furthermore, as mentioned above, the design and the implementation of the tests and the simulations differs from one research to another, consequently this provide different results of the studies. It should also be declared that the authors of the researches often are proponents of one of the

philosophies in particular, hence the results and the conclusions could be influenced by the opinions of the authors.

Although the ambiguous result was expected it was surprising to find out that so many research resulted in that TOC outperformed JIT. The Toyota Production System and the philosophy JIT have been frequently studied by researchers, universities and companies worldwide during the recent decades. An extensive number of literature exist on JIT, Toyota Production System and Lean Production. I believe it is of common opinion that JIT could be one of the most effective methods to use in order to improve the performance and the profit of the company. Maybe the reason why JIT is more popular is because it is more known. Perhaps TOC have not received as much publicity and attention as JIT.

Furthermore, regarding the matter of which of the philosophies is most suitable in a process environment with a high level of variability, it is not surprising that the majority of the results argue that JIT is less appropriate than TOC. The JIT philosophy originates from the Toyota Production System, a car manufacturing environment with a low level of variability. The philosophy was designed for this type of production processes, thus, the method is not aimed to be able to handle high variability.

To sum up, this paper provides a review of 19 different scientific sources, due to the limited number of literature considered the comparisons and the results of the review cannot be considered the complete truth. In order to achieve a more inclusive result, more articles regarding the issue have to be studied and the different results contemplated. Moreover, I recommend a more profound analysis of the different tests and studies with the aim to completely understand the results.

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