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THEORY OF CONSTRAINTS AND SIX SIGMA: INVESTIGATING DIFFERENCES AND SIMILARITIES FOR CONTINUOUS IMPROVEMENT

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ABSTRACT

The main objective of this study is to analyse some points of convergence and divergence between the Theory of Constraints and Six Sigma when used in an integrated manner for the continuous improvement of operating manufacturing systems. This research also aims to advance a better understanding of the fundamental principles of such methodologies by performing a comparative analysis of critical issues. The focus of the discussion of this study is to review the literature to identify the mains similarities and differences between these two approaches when applied in an integrated way in productive systems. To conduct this research, we carry out a broad literature review of the state of the art on the topic of Operations Management. The results of this study suggest that the Theory of Constraints and Six Sigma have many complementary elements that overlap and that a vast field of research must be explored on this issue. As a result, this study conducts a comparative analysis of 28 critical criteria of the Theory of Constraints and Six Sigma to understand these approaches.

Keywords: Theory of Constraints, Six Sigma, Continuous Improvement.

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1. INTRODUCTION

The main objective of this paper is to investigate the factors behind the convergences and divergences between the Theory of Constraints (TOC) and Six Sigma, when used as a combination for the continuous improvement of processes in manufacturing environments. The importance of this study is based on the extent of the use of approaches that focus on continuous improvement by organisations; as a rule, such approaches have reached their limit of performance given the current competitiveness and complexity of some markets. Moreover, it is necessary to find elements of other approaches to make more robust the current strategies that adopt continuous improvement in the face of global competitiveness.

Authors as Pirasteh and Fox (2011), Spector (2006), Montgomery (2010), Bendell (2006) and Bañuelas and Antony (2004) have studied a combination of approaches to provide integrated models of continuous improvement. However, from the literature review of the databases searched, no comparative studies have thus far discussed specific TOC and Six Sigma research focusing on the limits and possibilities of integration aimed at improving continuous operating. The gap evident from the lack of scientific articles discussing these two traditional approaches was therefore one of the main reasons for the development of this research. By carrying out a comparative analysis of the TOC and Six Sigma, this research also sought to objectively present their main similarities and differences in order to contribute to management decision making.

2. THEORY OF CONSTRAINTS

The TOC was developed during the 1980s by a physicist who had an outstanding knowledge of systems, Eliyahu M. Goldratt, and released in the form of the business novel *The Goal* in 1984. However, the origins of the TOC relate to the development of a software production schedule during the 1970s, known as Optimised Production Technology, also designed by Goldratt.

Nowadays, according to Inman, Sale and Green Jr. (2009) and Gupta and Boyd (2008), the TOC is defined as a management philosophy that provides a focus for continuous improvement that results in enhanced organisational performance. Boyd and Gupta (2004) defined the TOC as clearly identifying an “orientation to gain” along with its three dimensions: mental models, measures and methodology.

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Recently, research analysing the evolution of the TOC has been performed. Boyd and Gupta (2004) investigated the extent of the TOC by analysing Operations Management and obtained the following four findings. First, the TOC offers a new paradigm in Operations Management that replaces an outdated consensus to seek to achieve efficiency in the company, and thus the pursuit of the goal from a global perspective is more consistent with this new paradigm in Operations Management. Second, the TOC offers approaches to decision making in operations that can optimise company activities. Third, the TOC provides a criteria framework for Operations Management, but more empirical tests are needed to validate its operational practicality. Finally, the TOC can provide a unified theme or theory in Operations Management, thus offering new insights for researchers and practitioners.

In conclusion, owing to the improvement and development of the scope of the TOC over time, it is now beginning to be discussed and analysed from the perspective of becoming a valid theory in the field of Operations Management. This finding implies the need for research linking it to other relevant and related topics, such as the Six Sigma approach.

In order to advance the current understanding about the TOC, Inman, Sale and Green Jr. (2009) extended the model proposed by Boyd and Gupta (2004) and concluded that when fully implemented (in terms of logistics, thought processes and performance indicators), the TOC is an effective management philosophy. Moreover, the TOC results in positive outcomes such as increased profit, reduced inventory levels and operating expenses, thereby improving organisational performance. Further, contrary to the notion that orientation improves the gain directly according to the study of organisational performance by Boyd and Gupta (2004), Inman, Sale and Gree Jr. (2009) concluded that the relation between the TOC and organisational performance is completely mediated by the results of the TOC. That is, the implementation of the TOC does not directly influence the financial performance of the firm and market as proposed by Boyd and Gupta (2004). The conclusion is that the implementation of the TOC improves outcomes, which in turn positively affects organisational performance. Thus, the impact of the implementation of the TOC is felt primarily at the operational level, indicating which metrics related to the success of the TOC could focus on operational and organisational outcomes.

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3. SIX SIGMA

From a statistical point of view, the sigma is a measure of the intrinsic variability of a process, as defined by standard deviation (represented by the Greek letter sigma (σ)). Under normal conditions, the measure Six Sigma is two parts per billion. However, considering the fluctuation in a 1.5 sigma process from a long-term perspective, the process tends to operate at a rate of 3.4 defects per million, which effectively equates to 4.5 sigmas against the average (EHIE; SHEU, 2005). Thus, according to the concept arising from Motorola, although the moving average is 1.5 sigmas, the nominal value is expected to be 3.4 defects per million opportunities. Hence, if the standard deviation value is low, the process will be more uniform and there will be less variation in the results; in other words, the smaller the standard deviation, the better the process is and the lower is the possibility of failure (TRAD; MAXIMIANO, 2009).

Initially, Six Sigma focused on the manufacturing sector. However, with the maturity of the approach over time, it has gained strength in services, health, food and so on. According to Santos and Martins (2010), quality management has become increasingly important in terms of measuring, quantitative methods, specialised teams and clearly defined performance goals, Six Sigma thus is now used in a wider context as a recognised strategy to improve business performance.

Currently, by focusing on tangible opportunities for financial gain, organisations approaching Six Sigma's strategic issues define guidelines from a top-down perspective. The study by Pinto and Carvalho (2006) showed that firms that align Six Sigma projects with their corporate strategies have better performance than those who do not. In addition, other factors may be added as critical to the success of Six Sigma. The study of Trad and Maximiano (2009) listed the following factors:

(i) The leadership and participation of senior management: must be active and with clearly outlined and communicated,

(ii) The selection of projects: the right choice of projects aligned to the business strategy from the perspective of the customer and

(iii) Human resources: beyond the technical field of quantitative approaches, skills such as creativity, collaboration, dedication and communication are essential as is choosing the correct team.

Since the actual implementation of Six Sigma involves a series of steps

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focused on continuous improvement, the models adopted are Define, Measure, Analyse, Improve and Control (DMAIC) and Design For Six Sigma, which adopts the DMADV model (Define, Measure, Analyse, Design and Verify). The DMAIC model is designed and optimised for applications in existing processes and services in a manufacturing environment, while the DMADV model is adopted when new deployments of processes, products and services are made or when the current sigma level is already high, around five sigmas (BENDELL, 2006).

4. METHODOLOGY

This research aims to bridge the gap in the Operations Management literature in order to explain the similarities and differences between the TOC and Six Sigma for continuous improvement. The results of this discussion will generate new knowledge for the field of Industrial Engineering and Operations Management. Most academic research requires understanding the state of the art on the research problem. Thus, research is characterised as a theoretical review. For Khan et al. (2003), the main advantage of using a systematic review is that it provides information on the effectiveness of interventions to identify, evaluate and summarise the results of an amount of data not otherwise treatable. This research used as a basis the work of Silva (2009) and the study of Tranfield and Palminder (2003) to develop a systematic literature review. The procedure adopted for the literature review comprised the following six steps: (i) Extract keywords from the search problem: the words chosen were “Six Sigma” and “Theory of Constraints”, which were surveyed in the field “Abstract” in the databases; (ii) Define the databases to search for publications, namely Emerald, Springer Link, Scopus, Ebsco, Proquest and Scielo; (iii) Define the time horizon, namely 1995 and 2012; (iv) Review the titles and abstracts of publications. The study included 33 articles. However, between these studies, only Jin et al. (2009), Husby (2007) and Ehie and Sheu (2005) discussed the use of the TOC and Six Sigma for continuous improvement. These studies are detailed in Section 5 of this paper; (v) Decide on the inclusion criteria and; (vi) Carry out an analysis, synthesis and inclusion of the information in the search: this thread is consolidated in Section 5, which aligns the discussion of this research. A systematic review showed that integration between the TOC and Six Sigma is a recent theme in the literature and thus an opportunity for future research.

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5. COMPARATIVE ANALYSIS BETWEEN THE TOC AND SIX SIGMA

The Six Sigma approach identifies projects that can reduce defects in the process and make operational improvements. However, it does not fully involve operators and lacks a systemic view to understand how these projects affect overall system performance. According to Ehie and Sheu (2005), this aspect can lead to project prioritisation, no financial impact for the company and the elimination of positive impacts on other processes. Alternatively, Husby (2007) suggested that the five focusing steps of the TOC can bridge this gap. However, the author pointed out that the thought process of the TOC's analysis and troubleshooting uses language requiring complex intellectual driving by trained experts and a different approach for management and operators.

From the point of view of Jin et al. (2009), the focuses of Six Sigma and the TOC are the customer and the company. Although they have different philosophies, both have been used by various industries for process improvement because while Six Sigma requires solutions in depth, the TOC can show bottlenecks and overcome them. According to Nave (2002), the common form of integration between the TOC and Six Sigma is to identify the constraints of the company and use Six Sigma to reduce or solve this problem. According to Ehie and Sheu (2005), the main advantages of the combination of the two approaches are threefold. First, the restrictions are analysed, measured and controlled by using a set of statistical tools, thereby increasing the understanding of the problem and decisions. Second, the bottleneck is the first point to be analysed, thus generating increased financial gain for the company. Finally, the Six Sigma project is not chosen by a single business area, but rather based on the overall view that the TOC will generate project outcomes throughout the system.

However, according to Jin et al. (2009), the disadvantages are also threefold. First, it does not always reduce variation, which will increase the capacity of the restrictions. Second, when any reduction in variation elevates the production rate of the bottleneck, downstream processes can generate higher rates of rejection, with the focus placed on the bottleneck only. Finally, there is some uncertainty when applying the principles of the TOC and Six Sigma. The model integrating Six Sigma and the TOC proposed by Jin et al. (2009) assumes an environment with a limited budget for improving and applying Six Sigma after the bottleneck to ensure quality

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and efficiency. This model has been replicated in a motor manufacturing company with satisfactory results.

For Ehie and Sheu (2005), there are similarities between the improvement processes of Six Sigma (DMAIC) and the TOC (five focusing steps). The authors proposed an integrated model where the initial step is to identify the same restrictions in both approaches. The next step follows the logic of the TOC by exploiting the phase measures and analysing Six Sigma-like supports. Next, we use the Improve phase of Six Sigma and its statistical tools to eliminate the problems and causes indicated in the previous step. Step four uses the steps of the TOC and Control of Six Sigma to ensure that all actions taken previously are applied in the system. In step five, efforts are made to increase the capacity of the constraints, while the last step evaluates the next constraint to avoid inertia in the system. To refine the model, the authors suggested incorporating the TOC Thinking Process to understand the cause/effect interactions in the system as well as add other approaches aimed at continuous improvement. The study by Nave (2002) compared some differences between the TOC and Six Sigma and concluded that the two approaches are complementary. Similarly, Thompson (2005) contributed initially by enumerating a set of strengths, weaknesses and countermeasures to overcome any weaknesses, as shown in Table 1.

To consolidate the results of the literature review in an objective manner, Table 2 presents a comparative analysis of the 28 criteria of the TOC and Six Sigma. These criteria make it possible to understand the main similarities and differences between them. It is clear that the criteria Production Control, Production Planning, Inventory and Capacity Planning have no evidence in the Six Sigma approach. Complementary elements of each approach include the following criteria: Application Structure, Goal, Focus, Assumptions, Primary Effects, Secondary Effects, Distribution of Knowledge, Dominant Culture, Leadership Style, Information Technology and Management Performance Indicators. Likewise, conflicting aspects that hinder the use of the two approaches included Focus, Primary Effect, Deficiencies, Ease of Implementation, Hierarchical Level of Application, Structure Implementation, Effect on Variability, Process Aspects and Data for Application.

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Table 1: TOC vs. Six Sigma

Approach	Fundamental Elements	Strengths	Weaknesses	Countermeasures
Six Sigma	The cause of poor performance is the change in process and product quality. Random variation results in inefficient operations, causing customer dissatisfaction because of unstable products and services.	1. The rigour and discipline of the statistical approach solves complex problems that cannot be solved by simple intuition or trial and error.	1. Statistical methods are not well suited to analysing problems of integrated systems. One can calculate the sigma level for a product specification but not for the failure of processes and interactions.	1. Force 2 of the TOC
	Increased competitive advantage comes from stable predictable processes, allowing raising yields, improved forecasts and reliable performance by the product or service.	2. Data collection comes to managing strong subsidy support for decision making.	2. The heavy reliance on statistical methods by its very nature is reactive, since it requires the repetition of the process to develop trends and confidence levels.	
		3. The focus on reducing variation reduces risk and improves predictability.	3. The strong focus on stable processes can lead to a complete aversion to risk and may penalise innovative practices that are inherently unstable and variable.	
TOC	The cause of poor performance is failed management techniques. Logical systems are used to identify constraints and focus resources on restrictions. The constraint becomes the mainstay of management.	1. The TOC provides simplified resource management through a narrow focus on restrictions to manage a process as well as efforts to improve (exploration).	1. The emphasis on restrictions can lead actors to accept or tolerate excessive losses in cases of both no restrictions and a restricted environment.	1. Force 2 of Six Sigma
		2. It can see through all the processes in a system context to ensure that limited resources are not used to improve restrictions.		
		3. The TOC differentiates physical from political constraints. 4. It provides direction based on the appropriate indicators (G, I, DO)	2. The TOC does not forward directly the need for cultural change. The change process of the TOC is technically oriented and fully recognises the need for other methods of improvement.	

Source: adapted from Thompson (2005).

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Table 2 shows that the main relevance to managerial practice of this paper is that it presents to decision makers in the industrial context important points about the convergence and divergence between the TOC and Six Sigma when used in an integrated way for the continuous improvement of manufacturing systems. The survey results also allow managers and organisations to understand the limits and possibilities of each individual approach as well as their points of synergy for practical implementation in manufacturing systems as well as to increase productivity when exploring bottlenecks. Companies that already have elements of the TOC or Six Sigma implemented, or those that wish to apply them, may use this article as a reference to analyse the production system and prioritise integrated application based on the complementary strengths of each approach.

Table 2: Summary of the comparative analysis between the TOC and Six Sigma

Criterion	**TOC**	**Six Sigma**
1. Origin	Goldratt (1980s)	Motorola and General Electric (1980s)
2. Theory	Constraint management and increase gain	Reduce variability
3. Application Structure	1. Identify the constraint 2. Explore the constraint 3. Subordinate 4. Raise the constraint 5. Return to step 1	1. Define 2. Measure 3. Analyse 4. Improve 5. Control
4. Focus	On constraints	On problem
5. Goal	Continuous increase in profits	Maximise business results
6. Strategic Objective	Synchronise	Stabilise
7. Assumptions	- Emphasis on velocity and volume - Analyse existing systems - Interdependencies between processes	- There is a problem - Statistical tools are used - Improve the output rate of the system by reducing variation in processes
8. Primary Effect	Increase gain rapidly	Rate uniform process output
9. Secondary Effect	- Reduce inventories and losses - Gain is the benchmark of system performance - Improve quality	- Reduce losses. - Reduce inventories - Variability is the benchmark of managerial performance - Improve quality - Instigate cultural change
10. Deficiencies	Ignore parts of the organisation to focus on manufacturing and the constraint	- Interdependencies within the system - Improvements in processes made independently - Create elite employees
11. Ease of Implementation	Greater difficulty	Medium difficulty
12. Hierarchical Level of Application	Top management	Technical level and middle management
13. Structure Implantation	Jonah	Belts and Champions
14. Effect on Variability	Absorb variation	Reduce variation
15. Major Contribution	Systemic view of constraints	Organisational structure with experts in improvements, projects and guided

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		quantification of cost reductions
16. Process Aspects	- Metric-specific accounting - Focus on systematic constraints	- Specific statistical tools - Specific terminologies - Specific structure experts
17. Batch Size	- Larger batches for constraints and lower for non-bottlenecks	Not applicable
18. Production Control	The algorithm Drum-Buffer-Rope is used to release stock	Not applicable
19. Production Planning	- Detailed planning for constraints and less detailed for non-bottlenecks - Drum-Buffer-Rope	Not applicable
20. Distribution of Knowledge	Knowledge is centred and focused on constraints	Knowledge centred on belts and training is highly focused
21. Dominant Culture	- Requires a change in approach - Extends across all parts of the business	- Empowerment of employees - Change philosophy - Focus on customers
22. Leadership Style	Leader of driver profile	Leader of driver profile
23. Need for Data and Information	Amount and accuracy of data is less critical compared with traditional production methods	Requires a large quantity and a high accuracy of data for decision making
24. Inventory	- Inventory is needed to facilitate production, but the goal is to minimise inventory - Buffers are placed in front of the constraint and the intersection between the paths of non-bottlenecks and the path of a constraint to their production orders	Not applicable
25. Capacity Planning	- Consider finite capacity - Is planned by computer simulation	Not applicable
26. Information Technology	Computational resources are needed for deployment	Computational resources used mainly for statistical analysis
27. Stability Requirements for Deployment	Indifferent, but performs best in environments of medium or low stability	Indifferent
28. Management Performance Indicators	- Global Indicators: Net Profit (NP), Return on investment (ROI), Cash Flow (CF) - Local Indicators: Gain (G), Inventory (I), Operational Expenses (OE)	Defects Per Million Opportunities

Source: the author based on the literature review (2013).

6. CONCLUSION AND RESERACH AGENDA

This study analysed important factors about TOC and Six Sigma when used for the continuous improvement of processes in manufacturing systems. The discussion also contributed to a better understanding of the fundamental principles of such methodologies by performing a comparative analysis of aspects considered to be critical. After the analyses, it was found that examining the points of convergence

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and exclusion between the two approaches contributes to a better understanding of its fundamental principles. It was found in general that there are more points than aspects of overlap between the two approaches and that it is viable to think about constructing an integrated continuous improvement process that enhances competitiveness.

However, critical factors must be considered in constructing models integrating the two approaches, without which the development of a integrated model becomes weak. Among the main critical factors is that the literature still does not have a clear definition on such aspects as well as areas for opportunities for researchers:

- How to choose the correct elements of each approach according to the real needs of the organisation?
- How can the company precisely define its priority? To reduce variability? Or to reduce losses and improve flow? Or to remove constraints?
- The correct diagnosis on the culture, goals, strengths and weaknesses of the organisation should also be considered to be an aspect of the integration of the approaches.
- Another critical factor to be considered is the breaking of useful mental models, but how driving this change? For example, the non-effective engagement of operators is a characteristic of the cultural implementation of the TOC and Six Sigma;
- The principles of the construction of a model incorporating such approaches must necessarily be aligned with the company's strategy and goals. Top down or bottom up? In this sense, a starting point for future research on these topics can found in the discussion held in Pacheco et al. (2013) and Pacheco (2014).

In a general context, especially from the summary in Table 2, the results of this study showed that the TOC and Six Sigma have complementary aspects that overlap the points of exclusion and that there is a wide open field for research on the topic. Therefore, in order to advance the discussion and provide an in-depth understanding of the interrelationships between approaches or evaluate the contributions of other approaches, the following research topics also emerge for future research agenda:

- What indicators should be used to measure a performance model integrating the two approaches and how should we structure them (which levels) in the

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organisation?

- How can we choose what will be the dominant culture of the company and how should we build it, assuming that the approaches coexist?

REFERENCES

BAÑUELAS, R.; ANTONY, J. (2004) Six sigma or design for six sigma? **The TQM Magazine,** v. 16, n. 4, p. 250-263.

BOYD, L.; GUPTA, M. (2004) Constraints management: what is the theory? **International Journal of Operations & Production Management**, v. 24, n. 4, p. 370–371.

GUPTA, M.; BOYD, L. (2008) Theory of Constraints: A Theory for Operations Management. **International Journal of Operations and Production Management,** v. 28, n. 9/10.

EHIE, I.; SHEUS, J. (2005) Integrating six sigma and theory of constraints for continuous improvement: a case study. **Journal of Manufacturing Technology Management**, v. 16, n. 5, p. 542–553.

GOLDRATT, E. M.; COX, J. F. (1984) **A Meta**. 1.ed. São Paulo. Nobel.

HUSBY, P. (2007) Competition or Complement: Six Sigma and TOC. **Material Handling Management,** p. 51–55.

INMAN, R. A.; SALE, M. L.; GREEN Jr., K. W. (2009) Analysis of the relationships among TOC use, TOC outcomes, and organizational performance. **International Journal of Operations e Production Management**, v. 29 n. 4, p. 341–356.

JIN, K.; HYDER, A.R.; EIKASSABGI, Y.; ZHOU, H.; HERRERA, A. (2009) Integrating the Theory of Constraints and Six Sigma in Manufacturing Process Improvement. **Proceedings of world academy of science, engineering and technology**, v. 37.

KHAN, K. S.; KUNZ, R.; KLEIJNEN, J.; ANTES, G. (2003) **Systematic reviews to support evidence-based medicine.** London: Royal Society of Medicine Press Ltd.

NAVE, D. (2002) How to compare Six Sigma, Lean and the Theory of Constraints. **Quality Progress**, p. 73–79.

MONTGOMERY D. C. (2010) A modern framework for achieving enterprise excellence International. **Journal of Lean Six Sigma**, v. 1, n. 1, p. 56-65.

PACHECO, D. A. J. et al. (2013) Balanceamento de fluxo ou balanceamento de capacidade: análise e proposições sistêmicas. Ahead to print in in **Gestão & Produção**.

PACHECO, D. A. J. (2014) Teoria das Restrições, lean manufacturing e seis sigma: limites e possibilidades de integração. **Ahead to print in Revista Produção**.

PINTO, S. B.; CARVALHO, M. M.; HO, L. L. (2006) Implementação de programas de qualidade: uma survey em empresas de grande porte no Brasil. **Gestão & Produção**, v. 13, n. 2, p. 191–203.

PIRASTEH, R. M.; FOX, R. E. (2011) **Profitability with no boundaries**. Quality press.

ISSN: 2236-269X
DOI: 10.14807/ijmp.v5i2.150

SANTOS, A. B.; MARTINS, M. F. (2010) Contribuições do Seis Sigma: estudos de caso em multinacionais. **Produção**, v. 20, n. 1, p. 42–53.

SILVA, É. R. P. (2009) **Método para revisão e mapeamento sistemático da literatura** (DEI-POLI/UFRJ). Trabalho de conclusão de curso em Engenharia de Produção.

SPECTOR, R. E. (2006) How constraints management enhances Lean and Six sigma. **Supply chain management review**, v. 10, n. 1, Jan.-Feb., p. 42-47.

TRAD, S.; MAXIMIANO, A. C. (2009) Seis Sigma: Fatores Críticos de Sucesso para sua Implantação. **RAC**, Curitiba, v. 13, n. 4, art. 7, pp. 647–662, Out./Dez.

TRANFIELD, D.; PALMINDER, D. (2003) Towards a methodology for developing evidence-informed management knowledge by means of systematic review. **British Journal of Management**, 14, p. 207–222.

BENDELL, T. (2006) A review and comparison of six sigma and the lean organization. **The TQM Magazine**, v. 18, n. 3, p. 255–262.

THOMPSON, S. W. (2005) **Lean, TOC or Six Sigma: Which Tune Should a Company Dance To?** Society of Manufacturing Engineers. January 15, 2005. Disponível em:<http://www.sme.org/cgi-bin/get-newsletter.pl?LEAN&20030811&1&>.