ТЕМЕ, г. XXXIX, бр. 3, јул – септембар 2015, стр. 905–923

Прегледни рад
Примљено: 3. 9. 2014. UDK 005.6:658.513
Ревидирана верзија: 27. 5. 2015.
Одобрено за штампу: 18. 9. 2015.

LEAN CONCEPT TECHNIQUES FOR OVERCOMING CONSTRAINTS OF BUSINESS [a]

Ljilja Antić, Bojana Novićević Čečević*

University of Niš, Faculty of Economics, Niš, Serbia
**bojana.novicevic@eknfak.ni.ac.rs*

Abstract

In the business environment characterised by globalisation, the internationalisation of business, shortened product life cycle, the application of new production, information, and communication technologies, changes in the requirements of increasingly selective customers, etc., it is becoming more difficult to achieve, maintain, and improve competitive advantage. Numerous constraints stand in the way of achieving, maintaining, and improving competitive advantage. In different steps of the theory of constraints, the constraints that prevent the company and its divisions from achieving higher performance are identified, and the ways to mitigate their negative effects and overcome them are sought. The aim of this paper is the overview of possibilities of applying lean concept techniques in the theory of constraints, and analysis of their joint effect in the context of overcoming the different constraints in business operations, with the purpose of improving enterprise performance.

Key words: theory of constraints, lean concept, limiting factor, lean concept techniques, continuous improvement

ТЕХНИКЕ LEAN КОНЦЕПТА У ФУНКЦИЈИ ПРЕВАЗИЛАЖЕЊА ОГРАНИЧЕЊА У ПОСЛОВАЊУ

Апстракт

У условима пословања које карактеришу глобализација, интернационализација бизниса, скраћени животни циклус производа, примена нових производних, информационих и комуникационих технологија, промене у захтевима све пробирљивијих потрошача и друго, све је теже постићи, очувати и унапредити конкурентску предност. Бројна ограничења стоје на путу постизања, очувања и унапређења конку-

[a] The paper is realized in the scope of the project No. 179066 "Improving the Competitiveness of the Public and Private Sector by Networking Competences in the Process of European Integration of Serbia", funded by the Ministry of Education, Science and Technological Development of the Republic of Serbia.

рентске предности предузећа. На различитим нивоима концепта теорије ограничења идентификују се ограничења која онемогућавају предузеће и његове делове у постизању виших перформанси, изналазе се начини за ублажавање њихових негативних ефеката, као и за њихово превазилажење. Циљ постављен радом је сагледавање могућности примене техника lean концепта у реализацији фаза теорије ограничења и анализа њиховог заједничког дејства у контексту правзилажења различитих ограничења у пословању, а у сврху унапређења перформанси предузећа.

Кључне речи: теорија ограничења, lean концепт, ограничавајући фактори, технике lean концепта, стална унапређења.

INTRODUCTION

In a business environment mainly driven by information revolution, technology, and globalisation, changes are frequent, occurring in all spheres of social life, and their intensity and dynamics make companies' business unpredictable and risky. Under these business conditions, it is becoming increasingly difficult to achieve, maintain, and improve competitive advantage. In an attempt to adapt to changes in the business environment, and to successfully respond to the requirements of different stakeholders, companies change their production systems and organisational structure, implement new production information technology, new cost management, business process management, and company management concepts and methods. In most cases, the application of a single business concept, appropriate for the changed business environment, is not sufficient for the company to be able to respond to the challenges of maintaining and improving the competitive position.

One of the concepts that can be successfully applied in the process of continuous improvement, with the aim of maintaining and improving competitiveness, is the theory of constraints. A variety of constraining factors stand in the way of maintaining and improving the competitive position of companies on the highly competitive market. The theory of constraints rests on the improvement of the production process by focusing on the constraining factors, with the aim of increasing *throughput*, a special form of contribution, which is calculated as the difference between sales revenues and direct material cost. The constraining factors occur most often in the form of "bottlenecks" that prevent the company and its parts from achieving higher performance. Different steps of this concept involve identification of constraints and the examination of the ways to mitigate their negative effects, to prevent unnecessary spending of unlimited resources, and to eliminate the constraints. By directing the managers and employees' attention to the causes of the problems that arise in the process, this concept provides a good basis for process improvement, by reducing costs and eliminating non-value-added activities.

Modern companies, which undertake continuous efforts towards business process improvement, apply the lean concept principles in their business. Lean concept has proven to be extremely effective in business process improvement, long-term customer value creation, and securing of permanent competitive advantage, by eliminating unnecessary spending and improving employees' skills and competences. Companies that implement the lean concept through the use of sophisticated technology have the flexibility to gain advantage over the competitors by introducing small batches of products adapted to customer demands. The techniques that are applied in the lean concept provide strong support to the different steps of the theory of constraints.

Therefore, the research subject in this paper focuses on the techniques of the lean concept in terms of their implementation during different steps of the theory of constraints. The application of the lean concept techniques provides significant results in the field of exploitation and improvement of existing constraints. In addition, implementation of these techniques shortens the time of delivery, reduces cycle time, decreases inventories of finished products, and improves enterprise performance.

Therefore, the aim of this paper is the overview of possibilities of applying lean concept techniques in the theory of constraints, and analysis of their joint effect in the context of overcoming the different constraints in operations, with the purpose of improving enterprise performance.

In accordance with the set subject and aim of the research, the paper will test the following hypotheses: application of a single concept in the enterprise, whether lean or theory of constraints, leads to business improvement, but the best results are achieved through joint application of these concepts.

The defined hypotheses will be tested by means of methodological procedures and techniques, inherent in the social sciences. Starting with relevant literature, which contains the theoretical analysis, general conclusions about the considered problem will be obtained. The method used in the paper is that of comparison, and it is based on the comparison and emphasis of the basic characteristics of the lean concept and the theory of constraints. The method of classification is also used in the paper with the aim of indicating and explaining the lean concept techniques that are applied during different steps of the theory of constraints.

In this regard, the paper is divided into two parts. The first part presents the basic assumptions and levels underlying the theory of constraints. The second part is focused on the lean concept techniques, which constitute significant support to the theory of constraints.

THE CONCEPT OF THE THEORY OF CONSTRAINTS

The theory of constraints (TOC) emerged in the 1980s. Goldratt, the creator of this theory, sees the production process as a system, i.e. a set of interrelated and dependent elements. The overall performance of the whole system depends on the individual performance of each element, as well as on their joint effect. In fact, such a system involves the realisation of a number of activities that are connected in a continuous chain. Each activity in the chain has its maximum capacity. The link in the chain that does not use its maximum capacity and does not contribute to the achievement of the defined goal of the entire system is considered to be a constraint. Constraints may arise due to the lack of physical resources, such as the space of the production facility, warehouse, machine capacity, the capacity of the means of transport, etc. The constraint may often appear in the form of limited demand for certain products on the market, managers' way of thinking, and the like. The constraint, therefore, is everything that prevents and slows down the company's goal realisation and the implementation of the defined strategy (Gupta & Boyd, 2008). The constraints can be classified in different ways. In most cases, constraints are classified as physical constraints, business policy constraints, paradigm constraints, and market constraints (Antić & Stevanović, 2011). Physical constraints usually include those that are related to the equipment, but, in practice, the physical constraint may appear as material shortage, lack of people, or lack of space. Business policy, as an accepted way of working, can become a constraint that prevents the achievement of higher performance and goals. This is primarily related to the adopted procedures applied in the company, the defined strategy, as well as the state regulations. As a constraint, the paradigm is related to deeply-rooted beliefs and habits of managers at all levels, as well as the direct operators. As an example, we can cite the deeply-rooted belief that the machine constantly running will reduce the cost per unit of a product. Market constraint occurs when the product range by far exceeds the product demand.

In order for a company to achieve, maintain, and improve its competitive position on a highly competitive global market, it is essential that managers recognize the factors, i.e. constraints that exist in the company, and find the ways to overcome them and eliminate them. Specifically, the company's management must find answers to the following fundamental questions (Gupta, Baxendale, & McNamara, 1997): a) What needs to be changed?; b) What should it be changed to?; and c) Which actions will cause the change?

In addition to these, Goldratt (1990, p. 19) points out the following questions that managers must find the answer to in order to successfully lead the company towards a defined goal realisation: a) How much money is generated by our company?; b) How much money is trapped in our company?; and c) How much money should we spend to achieve it?

Thus, Goldratt (1990, p. 19) defines global measures of the TOC: *throughput* (which is calculated as the difference between the sales revenue and the direct material cost, referring to the "fresh" money coming into the company), *inventory* (money invested in the purchase of things that the company intends to sell), and *operating expense* (money that a company spends to turn inventory into throughput).

Through five steps, the concept of the TOC identifies business constraints and determines how they could be minimised and eliminated. This is a top-down concept, which determines where and how to focus the efforts towards improving performance. Five steps of the TOC are the following (Dittmer, 2005; Gupta et al., 1997; Weil, & Maher, 2005):

1. *Identify the system constraints*. In this step of the TOC, the production process is reviewed in order to identify constraints. The possibility of identifying the constraints depends on the types of constraints. It is easier, for example, to identify the physical constraints than other types of constraints. For example, the production phase, which represents the "bottleneck", can be identified by finding the phase in the product processing with large accumulation of work-in-process.

2. *Decide how to exploit the constraint systems*. After identifying the constraints in the first step, in the second step it is necessary to make appropriate decisions about how to use constraints and consider opportunities to increase process performance within the identified constraints. If there is a constraint in the available resources used for the production of products for which there is demand on the market, the company will not be able to respond to customer demand and will have to prioritise the use of the constrained resources. The existence of only one constraint simplifies the situation because the priority will be given to the production of products that have the highest throughput per unit of the constrained resource. The situation is more complicated if there are several constraints, because the decision on how to use the constraint in the best possible way will require additional analysis.

3. *Subordinate everything else to the decision in step 2*. In this step of the TOC, it is necessary to take all measures to prevent unnecessary waste of non-constrained resources. In fact, all the activities to be undertaken shall be in accordance with the decisions made in the previous step. All processes must be consistent with the capacities of the bottleneck. The machine that is the bottleneck, for example, dictates the pace of processing on the machines that are not the bottleneck. The machine that is not a bottleneck will process as many parts or products as the machine that is the bottleneck can handle.

4. *Elevate the system constraint.* In this step, the possibilities to overcome the identified constraint and mitigate its negative effects on the operations of the individual elements of the system and the system as a whole are considered. If the current constraint has not yet been removed,

the possibilities for its further improvement and actions to be taken to eliminate it are examined. The manager's attention is focused on process simplification, product design improvement, setup time reduction, and minimisation of downtime occurring in the process. Increasing the capacity of the bottleneck can be achieved in different ways (Antić, & Stevanović, 2011; Weil, & Maher, 2005):

- parts, components, and work-in-process should be controlled prior to their passing through the constraint. If we identify units of inadequate quality after processing on the machine that is the bottleneck, we reduce the overall production and sales;
- the machine that is the bottleneck must be constantly running, and its maintenance should be carried out during holidays, weekends, or after working hours;
- the possibility should be taken of hiring additional workers, whose task will be to move the finished parts and prepare the machine for processing the following batch of products after processing one batch of products on the machine that is the bottleneck. In this way, it will reduce or eliminate the idle time of the machine. Such a way of overcoming the bottleneck will be acceptable if the cost of hiring additional workers is lower than the throughput realized through the sale of additional units of the product;
- the possibility of using the services of other companies should be considered if the costs of using their services are lower than the throughput obtained by the sale of additional units of the product.

5. *Go back to step 1, but don't allow inertia to cause a system constraint*. If the constraint has not been removed in the previous steps, it is necessary to return to the first step, because it is likely to reveal the new constraint, which should be used, prioritised, and overcome.

Steps of the TOC can be schematically described as in Figure 1.

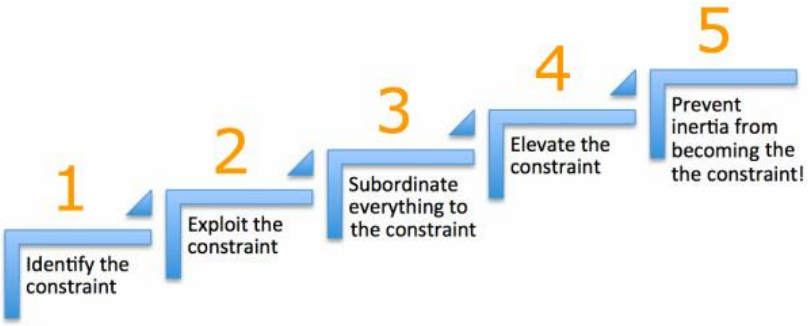

Figure 1. Five steps of the TOC
Source: http:///www.tocinstitute.org/five-focusing-steps.html

The presented and explained steps of the TOC are part of a process of continuous improvement. In this regard, a continuous flow of the steps

of the TOC never ends. When an existing constraint is eliminated, the process is re-examined, and a new potential constraint that may arise is sought.

The concept of the TOC observes and analyses the processes, potential operational problems, and conflicts. The goal, therefore, is to find all the things that can slow down the processes and cause reduced productivity. After identifying the problems and conflicts, managers focus their efforts on their elimination. In order to resolve the problems and conflicts in the processes, the TOC proposes a number of "applications", which focus on specific functions in the company (Zylstra, 2002, p. 6). These "applications" enable quick assessment of problems and formulation of specific actions and plans, and facilitate the management's successful implementation of solutions to problems and conflicts. Conflicts that arise are different and can be classified by functions in the company. The summary of conflicts and "applications" by various functions is given in Table 1.

Table 1. TOC conflicts and "applications"

Function	Conflict	Application
Operations	Throughput *versus* reduce costs	Focus on throughput, profitability will follow
Measures	Cost accounting *versus* profitability/cash	Performance measures based on T-OE (throughput – operating expense) and investment
Project Management	Complete each project task on time *versus* complete the entire project on time	Manage project buffers, not individual task buffers
Supply Chain	Reduce supplier prices *versus* reduce total supply chain costs	Link suppliers' conflicts with internal core problem
Marketing	Price based on our cost *versus* customer value	Negotiate agreements to resolve customer's conflict
Sales	Sell based on price/terms *versus* customer core conflict	Sell conflict resolution
Human Resources	People as emotional beings *versus* thinking machines	Use TOC thinking processes
Strategy	Product & market investments *versus* flexibility	Strategies to open up market constraints

Source: Zylstra, K. (2002) Lean and TOC: Leverage the Best of Both available at: http://profit-chain.com/images/lean_and_toc_paper.PDF

According to the proponents of the TOC, the costs are largely fixed, and should not be allocated to products, as efforts aimed at their reduction do not directly imply the profit increase. The three measures arising from the TOC (throughput, inventory, and operating expense) are quite sufficient to establish a "bridge" between the net profit (net profit – NP, which, according to this theory, is calculated as the difference between the

throughput and the operating expense), return on investment (return on investment – ROI, which, in this case, is calculated as the ratio between the net profit and inventory), and managers' everyday actions (Carbett, 2000, p. 39).

Each decision of the managers, which has a positive impact on the return on investment, helps the company achieve its defined goals. During evaluation and assessment of any management activity and their decisions, "one should bear in mind that there are three measurements, not just one", because, if it is not taken into account, the action will not be evaluated properly, whereas the "final judgment will be made on the basis of relations among the above measurements" (Goldratt, 1990, p. 32). To determine the basic measurements, net profit and return on investment in the manner defined in the TOC, it is not necessary to allocate costs to products.

THE LEAN CONCEPT AS A SUPPORT TO THE CONCEPT OF THE THERY OF CONSTRAINTS

Lean production philosophy can be characterised as a market-oriented, integrated, and flexible system, which involves a high degree of internal and external coordination of business activities, with fast and frequent flow of products and information (Levy, 1997, p. 95). As such, the lean production philosophy implies the delivery "just in time", elimination of waste and inventory, continuous quality improvement, reduction of defects and downtime, shortening of time of response to customer demands, flexible small-batch production, establishment of close cooperation with the suppliers, and the like (Sekerez, 2009).

The term "lean production" was first encountered in the book "The Machine That Changed the World", written by Womack and Jones. However, the term "lean concept" itself is associated with the Toyota company, i.e. the production system applied in this company. Lean concept involves a multi-dimensional approach that encompasses a number of management practices, including just-in-time, quality system, teamwork, cell production, and relations with the suppliers, seen as an integrated system (Kennedy & Widener, 2008). These management practices enable the creation of high-quality products at a time when consumers have a need for them, with little or no loss and waste. Five key elements that characterise lean production are: production flow, organisation, process control, metrics, and logistics (Dittmer, 2005, p. 9). Production flow is based on the grouping of related activities in the production cell. Employees perform their tasks within the production cells, communicating in a new way. Scheduling employees' lean work organisation is in the charge of the organisation. Monitoring, analysis, and improvement of employees' work are in the charge of the process control. Metrics builds performance measures that demonstrate achievements and progress in teams' work, whereas logistics defines the rules and mechanisms for the material planning and control.

The process of establishing the lean production concept begins with the mapping of the physical state of the processes in the company, i.e. the "value stream" mapping. The "value stream" map is a picture of all the processes that take place in the company, from the procurement of raw materials from the suppliers to the delivery of finished products to the customers. In the process of "value stream" mapping, multidisciplinary teams participate, which separately list the value-added processes and non-value-added processes. The number of processes in the "value stream" map depends on the size and complexity of the company. Thus drawn, the "value stream" map is a guide for managers to focus their efforts on the places where the improvement is needed and to focus on specific goals. After identifying the "value stream" map, the application of the lean concept techniques follows, in order to improve the process. These techniques range from those aimed at reducing the setup time to those that reduce the space for the performance of certain processes.

Therefore, the lean concept implies a long-term process of eliminating waste and continuous improvement, in which all employees participate. It implies constant and uncompromising product flow improvement. The lean concept focuses on the reduction of non-value-added activities, thereby shortening the production cycle, eliminating inventories, reducing costs, and making many process improvements visible.

The similarities between the lean concept and the TOC are reflected in the following (Dittmer, 2005, p. 14):

- observing the company as a comprehensive system,
- adhering to the principle of continuous improvement,
- the goal of business is to increase profit,
- value is defined by the customer,
- value stream is a broader concept than production,
- quality is the key to success,
- production of small-scale batches,
- pull production system (production based on the orders, not for the warehouse),
- minimising inventories, and
- participation of all employees in the company's success.

Lean concept and TOC focus on the customer, who is supposed to give a final judgment about the delivered value. The value is reflected in the production of high quality and defect-free products, with minimal capital investment and workers' efforts, in a shorter period (Novićević, Antić & Stevanović, 2013, p.145). In this regard, these concepts are based on the fact that quality is crucial for the success of companies on the market. To ensure the desired product quality, lean concept views the whole process through the value stream, which is a broader concept than the process of production. The focus of TOC is broader, and it includes the entire value chain. For the successful implementation of these concepts, it is necessary

to ensure continuous product flow through enterprise in small batches. This leads to a significant reduction in inventories of work in process and finished goods, and the creation of available capacities. In this regard, both concepts focus on the process of continuous improvement that will increase company profits.

The joint application of these two concepts results in the continuous company's business improvement. The techniques that are used within the lean concept support the described steps of the TOC. The display of the lean concept techniques by steps of the TOC is shown in Figure 2.

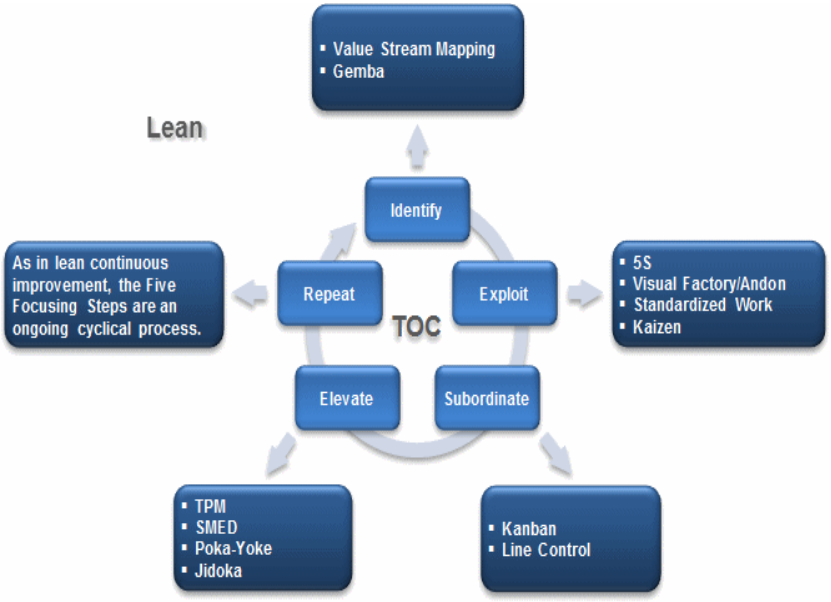

Figure 2. The display of the lean concept techniques by steps of the TOC
Source: http://www.leanproduction.com/theory-of-constraints.html

In the first step of the TOC, the "value stream" mapping and Gemba, as the lean concept techniques, support the process of identifying the constraints that exist in a company.

The importance of the **"value stream" mapping** is reflected in the creation of images of all the processes that take place in the company. Well-performed "value stream" mapping is the starting point for the company's business improvement. It shows all the activities performed in the company – from the entry of the raw materials to the delivery of finished products to customers. The map shows only value-added activities, i.e. the idealised production process realised without interruption and downtime. The elements of the "value stream" mapping are (Hickey, Dacruz, & Seaver, 2003):

- the steps of the process – containing information on: cycle time, time of value-added activities and non-value-added activities, number of employees, inventories, etc.,
- inventories – showing the movement of inventories,
- information flow – indicating the needed information about orders, delivery schedule, and the like,
- indicators: lead time, cycle time, processing time, and value creating time.

The first step in the "value stream" mapping is the choice of a family of products that need to be improved. After the selection of product families, it is necessary to draw up the map of the current situation. For mapping the current situation, material flow and information flow are important. The material flow is shown in the lower part of the map, while the information flow is recorded in the upper part. Information flow is drawn from right to left, and is connected with the material flow. After the presentation of the current situation, it is necessary to map the future state. In the map of the future state, it is possible to spot the sources of waste and parts of the process that need to be improved. In the end, it is necessary to apply the map of the future state to the current "value stream". The formation of the value stream map provides information on the functioning of the entire system of value creation, which forms a basis for the identification of possible constraints in operations. By documenting difficult business processes that are performed in the enterprises, it is possible to form the teams that will be capable of resolving problems and eliminating possible constraints.

Managers, engineers, and direct operators draw up a flow diagram of the processes that are performed in the company. The flow diagram shows the parts of the process and the time required to perform certain activities in the process (Blocher, Stout & Cokins, 2010). To identify constraints, takt time can be used as an efficient tool. Takt time is obtained as the ratio of available production capacities and demand for products, and stands for the rate at which products should be produced in order to adequately respond to the customer demands. The result of this relationship is the time period for which each unit of product should be produced. The constraint is identified by comparing the time it takes to complete an activity and the time actually spent for its performance.

Gemba technique requires that managers leave their offices and spend the working hours in places where the production process takes place. This method allows a better understanding of the production process itself and its more detailed analysis. Regular visit to the facility in which the production process takes place and its careful observation may be the best way to identify the constraints.

Increasing process performance within the existing constraints in the second step of the TOC can be achieved by using the following lean concept techniques: 5S, visual factory, standardised work, and Kaizen.

5S technique begins by scanning the existing work areas. Scanning can provide information on the current business conditions. This technique is related to the following five elements (Gerhard, 2007, p. 249):

- *Sort* – separation of the things that are needed and the ones that are not needed,
- *Set in Order* – organisation of the work area,
- *Shine* – clean up and move everything that can create problems in the work,
- *Standardise* – implement procedures and ensure their understanding by the workers, and
- *Sustain* – set the system to function with full communication, based on the principle of continuous flow.

The application of the 5S technique begins by identifying the items that are necessary to carry out the process. The material, supplies, equipment, and tools are sorted in accordance with the purpose and the degree of use. Then, the items that exist in the process, which are not needed for the process realisation, are identified. Such separation of items that are used and those that are not used greatly facilitates the flow of material and people. After the sorting, only the necessary items will remain in the work area. After that, it is necessary to decide where to keep the items that are required to perform the activities in the process, as well as the items that are not needed. The space should be arranged so that the items that are necessary for the smooth realisation of the process are placed in a prominent and easily accessible place. Unnecessary items are removed from the work area. The work area and all the necessary equipment should be cleaned, and the cleaning methods and agents defined, i.e. the procedures to be followed by all employees. Sorting, setting in order, and shining must become a habit and seep into the consciousness of employees. The employees' progress should be made visible and rewarded. Finally, the established 5S process needs to be maintained, by motivating employees and organising the proper training. Through the organisation of the work area and elimination of unnecessary waste, the 5S lean technique provides a good basis for improving the second step of the TOC. The 5S technique creates a basis for better performance of the activities that have been identified as constraints, enables faster response to the resulting constraint, and increases motivation and enthusiasm of employees (http://www.leanproduction.com/theory-of-constraints.html).

Visual Factory is the lean concept technique which rests on the premise that one picture is worth a thousand words. Data about the process realisation are obtained by visual observation of the processes themselves and the creation of the picture of their realisation. If the data about the process are available at a time when there is a need for them, it is possible to improve the company's business. The goal of this technique is to allow the workers to have full control over their work area (Tapping, Luyster & Shuker, 2002). By directing the efforts of employees through the use of

visual tools, this technique allows the improvement of the identified constraints. In addition, this technique encourages the emergency response to the problems caused by the constraint, as well as the real-time measurement of constraints.

Standardised work implies that the best work practice should be applied to all areas of the business. This technique involves the documenting of the processes that take place in the company in order to harmonize the existing work practice with the defined takt time machine and achieve a given cycle time. In order to standardise the work process, employees and managers need to work together in order to establish the most effective work methods. The standardised work process will bring takt time in line with the cycle time. Through work standardization, it is possible to increase throughput by applying the best business practices in places where the constraints are found. In this way, these techniques will lead to increased process performance and improve the second step of the TOC. In addition, reducing variations by implementing standardized procedures in places where constraints occur ensures a continuous flow of performance of all activities in the enterprise.

Kaizen technique involves active and committed involvement of all employees, from the top management to the direct operators. This technique advocates work in small groups, which is aimed at product and business process improvement during the production phase. Joint work leads to incremental changes in the production process. Kaizen technique also encourages communication among employees, managers, experts, and operators, better utilisation of work equipment and available company's resources. Taking advantage of the employees' competences leads to continuous improvement. This technique, applied as the support to the second step of the TOC, allows the following (http://www.leanproduction.com/theory-of-constraints.html):

- generating ideas on how to exploit the constraint,
- identifying opportunities for increasing throughput of the constraint unit, and
- motivating employees to work as a team and critically think about their work.

Kanban and Line control are the lean concept techniques responsible for reviewing all activities in the process in order to prevent unnecessary spending of non-constrained resources and synchronise with the capacities of the bottleneck.

Kanban technique focuses on regulating the harmonious material flow. This technique ensures automatic replenishment where necessary. Some authors believe that Kanban is the heart of the pull production system (Tapping, Luyster & Shuker, 2002). Inventories of materials are shown by cards and are available when they are needed, where they are needed, and in quantities that are needed. Business process improvement

on the basis of this technique relates primarily to the reduction in inventories, which is achieved by: reducing replenishment lead time, reducing production rate, and reducing changes in the product demand (Wilson, 2010, p. 50). By establishing control of the material flow and synchronising the use of the material in the places where the constraints occur, Kanban technique supports the third step of the TOC.

Line control is the lean concept technique that regulates an arrangement of work elements in the "value stream" itself in order to achieve takt time. This technique helps the employees perform their tasks and duties efficiently. The task of this technique, starting from the current situation shown in the diagram that contains all the elements of the work process, is to locate the places where it is necessary to make improvement. This lean concept technique is important for achieving the goals of the TOC, because it allows optimisation of the constraint, increase in the speed of the process realisation, maximisation of the throughput, and reduction of interruptions. In addition, through better synchronisation of work, this technique leads to a reduction of time required for the beginning of the production process.

Mitigating the effects of existing constraints and finding the ways to overcome them in the fourth step of the TOC is supported by the following lean concept techniques: Total Productive Maintenance (TPM), Single-Minute Exchange of Dies (SMED), Poka-Yoke, and Jidoka.

Total Productive Maintenance (TPM) offers a holistic approach to the activities of maintenance of machines and equipment. TPM includes activities that are carried out to prevent machine failures, minimize machine downtime, and make the machines and equipment safe and easy to handle. TPM is a powerful tool for enhancing the performance of the production process. The basis of this technique includes: the improvement of activities, automatic maintenance, system for planning maintenance, training of employees responsible for maintenance, and the preventive maintenance system (Wilson, 2010, p. 63). TPM is the proactive approach that increases the efficiency of machines and maximises the work time of the constraints. This technique of the lean production concept allows reduction of the frequency of constraint, minimisation of the machine downtime, making of the maintenance plan, making the plan and schedule for non-production time, and quality improvement by finding and removing the roots of defects (http://www.leanproduction.com/theory-of-constraints.html).

SMED is another technique of the lean concept for the reduction of waste in the production process. This technique ensures rapid and efficient transformation of the production process in order to transition from the production of the current product to the production of the following product. This technique shortens the changeover time, increases the degree of utilisation of machines, and allows timely delivery, which leads to cost reduction. SMED technique consists of five stages (Cudney, 2009, p. 90):

- determination of the setup operation,
- preparation, after-process adjustment, and checking of material and tools,
- mounting and removing of blades, tools and parts,
- measurement, setting, and calibrations, and
- trial runs and adjustment.

The first phase determines the areas that will be subject to improvement. It is important to consider the time reduction from the aspect of the entire "value stream", and not in terms of individual machines. In the second stage, the conditions for easy accessibility and running of all tools and equipment should be created, which will significantly rationalise the process. Moving parts and tools immediately after the completion of the production of the liquid product, and quick preparation of the machines for the production of the following product is the task of the third stage of this technique. The fourth stage of this approach focuses on the calculation of the indicators during production operations. If the measures in the fourth stage are well-defined, it will be easier to perform and monitor improvement. SMED technique provides a drastic reduction of the time spent on setting up the machine, which is a constraint to achieving higher performance. SMED is of great benefit to the fourth step of the TOC because it (http://www.leanproduction.com/theory-of-constraints.html):

- increases productivity within the existing constraints,
- enables smaller batch sizes and efficient responsiveness to customer demands, and
- enables normal process startup, by simplifying and standardizing the various settings required for the transition from the current production to the production of the next product, which leads to higher quality and overcoming of constraints.

Poka-Yoke technique is an important tool for the control of activities and processes, focusing on the prevention of errors, prevention of downtime, and prevention of deviations from the defined standard procedures, which leads to lower costs and higher quality. Special attention is given to the control of the installation of small parts needed to complete the final product, which significantly affect its usability. The name of the technique is derived from the word Poka – unintentional error, and Yoke – testing and prevention of errors. Business with zero defects forms the basis of this technique. As we pointed out in the fourth step of the TOC, it is necessary to ensure that only faultless parts reach the machine that is the bottleneck, i.e. the constraint, which will prevent unnecessary spending of scarce resources, which the application of Poka-Yoke technique allows.

As another lean concept technique, **Jidoka** allows continuous business improvement by detecting errors and correcting them at the earliest stage, i.e. at their very source. If the possible problems are detected in

the process, they are immediately solved by finding the cause of the problem. The process will not continue until the cause of the downtime has been fully eliminated. This technique refers to automation with the human factor and entails a high level of authorisation and responsibility of employees to stop the production process if irregularities are detected. This technique allows, in the fourth step of the TOC, the prevention of unnecessary spending of scarce resources and ensures that the high quality parts necessary to complete the finished product get to the machine that constitutes the constraint.

Application of lean techniques at the previous steps of the TOC will ensure the smooth functioning of the system that provides value to the consumers. This is because the application of the concept of lean techniques ensures transparency of the entire process, which will result in the clear identification of business constraints. Once you remove the existing constraints, it is necessary to return to the first step and re-examine the entire process, because it is likely that you will discover a new constraint.

CONCLUSION

Modern concepts that could be applied in the process of continuous improvement are, among others, the TOC and the lean concept. Essentially, both concepts tend to eliminate non-value-added activities through the removal of constraints and excess waste. They are aimed at flawless functioning of the company without downtime and interruption, with the purpose of business cost reduction and timely delivery of the required value to the customers.

TOC is an effective concept that allows company management by focusing on the process of continuous improvement. In this regard, the identification of business constraints and constant striving for their removal are crucial for establishing the flow of products through the entire value chain. In order to eliminate constraints in different steps of the TOC, it is possible to apply certain lean concept techniques.

In this regard, the contribution of lean concept techniques is reflected in the following:

- Creating an adequate basis that will clearly indicate the existence of any constraints. By using the value stream map, managers will have a clear picture of business process performance and of places where constraints occur. In this way, they will be able to quickly respond to existing constraints.
- They provide a basis for exploiting constraints, by using standard procedures and engagement of all employees in business improvement process. Starting from the working conditions and applying the best work practices ensures better utilization of available resources.

- They prevent unnecessary waste of resources by establishing a flow of materials and synchronization of labour and machines.
- They provide a basis for increase of the productivity of business within the limits of the existing constraints. Increased productivity implies an increase in the production process and all supporting activities.

In order to successfully apply these concepts, it is necessary to start from the strategic level and encourage lower levels of the organization to accept the basic principles of these concepts. In practice, application of these concepts multiplies better results.

This paper pointed out the concept of lean techniques that can be applied at different steps of the TOC. In addition, it presented the contribution of each of the techniques of lean concepts to business improvement and elimination of constraints. The paper highlighted the common characteristics of these concepts that represent a key mechanism for achieving competitive advantage.

The research in this paper focused mainly on the understanding of the theoretical aspects of the application of lean concepts techniques in the appropriate steps of the TOC. The study of this problem has opened up many questions and dilemmas related to the common application of these concepts. Further analysis of these issues will attract attention of researchers in the future. Furthermore, the authors' attention in future research will focus on the possibility of applying these concepts in enterprises' operations in Serbia. This is because the practical application of lean concepts and the TOC yields amazing results in terms of cost reduction, reduction of inventories, shortening of lead time, and the like.

REFERENCES

Antić, Lj., & Stevanović, T. (2011). Backflush costing and throughput accounting. *Themes*, 03, 1011-1032.

Blocher, E.J., Stout, D. E., & Cokins, G. (2010). *Cost Management, a strategic emphasis*, 5th edition. New York, NY: McGraw-Hill.

Carbett, Th. (2000). Throughput accounting and activity based costing: The driving factors behind each methodology. *Journal of Cost Management*, 1, 37-45.

Cudney, E. (2009). *Using Hoshin Kanri to Improve the Value Stream*. New York, NY: Productivity Press.

Dittmer, W. H. (2005) *Beyond Lean Manufacturing: Combining Lean and the Theory of Constraints for High Performance*.

available at: http://goalsys.com/books/documents/TOCandLeanPaper-rev.1.pdf

Gerhard, P. (2007). *Reinventing Lean: Introducing Lean Management into the Supply Chain*. United State, US: Butterworth- Heinemann.

Goldratt, E. (1990). *The haystack syndrome. Sifting information out of the data ocean, Croton-on-Hudson*. New York, NY: North River Press.

Gupta, M., & Boyd, L. (2008). TOC: a theory for operations management. *International Journal of Operations & Production Management*, 28(10), 991-1012.

Gupta, M., Sid, B., & McNamara, K. (1997). Integrating TOC and ABCM in a health care company. *Journal of Cost Management*, 4, 23-33.

Hickey, P., Dacruz, M. & Seaver, S. (2003). *Benchmarking Lean Manufacturing and Theory of Constraints Implementations*. available at: http://www.public.navy.mil/airfor/nae/AIRSpeed%20Documents/Benchmarking%20Lean%20and%20TOC.pdf

Kennedy, A., & Widener, S. (2008). A control framework: Insights from evidence on lean accounting. *Management Accounting Research*, 19, 301-323.

Levy, D.L. (1997). Lean Production in an International Supply Chain. *Sloan Management Review*, 4, 94-102.

Novićević, B., Antić, Lj., & Stevanović, T. (2013). Koncepti upravljanja troškovima u funkciji realizacije konkurentskih strategija [The concepts of cost management in the function of realizing competitive strategy]. Niš: Ekonomski fakultet.

Sekerez, V. (2009). Izazovi obračuna troškova u uslovima lean proizvodnog okruženja [Challenges of cost accounting in terms of lean production environment]. In: Čanak, J. (Ed): *40 godina računovodstva i poslovnih finansija – dometi i perspektive* [*40 years of accounting and business finance – achievements and prospects*] (311-333). Zlatibor: Savez računovođa i revizora Republike Srbije.

Tapping, D., Luyster, T., & Shuker, T. (2002). *Value Stream Management.* New York, NY: Productivity Press.

Weil, R., & Maher, M. (2005). *Handbook of cost management.* New York, NY: John Wiley & Sons.

Wilson, L. (2010). *How to Implement Lean Manufacturing.* New York, NY: McGraw-Hill.

Zylstra, K. (2002). *Lean and TOC: Leverage the Best of Both.* available at: http://profit-chain.com/images/lean_and_toc_paper.PDF

www.leanproduction.com/theory-of-constraints.html (20.01.2014.)

www.tocinstitute.org/five-focusing-steps.html (01.02.2014.).

ТЕХНИКЕ LEAN КОНЦЕПТА У ФУНКЦИЈИ ПРЕВАЗИЛАЖЕЊА ОГРАНИЧЕЊА И ОЧУВАЊА КОНКУРЕНТНОСТИ ПРЕДУЗЕЋА

Љиља Антић, Бојана Новићевић Чечевић
Универзитет у Нишу, Економски факултет Ниш

Резиме

Унапређење конкурентске позиције предузећа на глобалном висококонкурентном тржишту изискује познавање ограничавајућих фактора и изналажење начина за њихово превазилажење и отклањање, као и елиминисање свих губитака до којих долази у пословању. Предузећа примењују бројне нове концепте да би одговорила на изазове измењеног пословног окружења, између осталих и теорију ограничења и lean концепт. У основи оба концепта је тежња да се елиминишу активности које не додају вредност путем отклањања ограничења и сувишног отпада. Оба концепта теже беспрекорном функционисању предузећа без застоја и прекида у обављању пословних процеса, што за резултат има ниже трошкове пословања и благовремен одговор на захтеве све пробирљивијих потрошача.

У фокусу интересовања теорије ограничења јесу управо ограничавајући фактори, који детерминишу перформансе осталих процеса у предузећу и онемогућа-

вају остварење постављених циљева предузећа као целине. Теорија ограничења је усмерена на унапређење производних процеса с циљем минимизирања или потпуног отклањања негативних ефеката ограничења. Успешно управљање ограничењима представља процес који се одвија у пет нивоа, и то: ниво идентификовања ограничења система, ниво повећања перформанси у границама постојећих ограничења, ниво спречавања непотребног трошења неограничених ресурса, ниво ублажавања ефеката постојећих ограничења, као и ниво провере ефеката ублажавања.

Lean концепт пословања у први план истиче вредност која се испоручује потрошачима уз елиминисање непотребног трошења и активности које не додају вредност. Lean концепт подстиче стална настојања да се „ток вредности“ унапреди кроз оперативне активности уз отклањање свих могућих ограничења и елиминисање свих врста отпада. У том циљу овај концепт је развио бројне технике управљања, као што су мапирање тока вредности, 5S, визуелна фабрика, стандардизација рада, тотално продуктивно одржавање, SMED, Poka-Yoka, Jidoka и друго.

Ове технике управљања могу бити успешно примењене као подршка појединим нивоима концепта теорије ограничења. Тако, мапирање тока вредности у оквиру пословних процеса представља добру основу за увид у одвијање процеса, што олакшава идентификовање ограничења, као исхода првог нивоа теорије ограничења. Технике управљања, као што су 5S, визуелна фабрика, стандардизација рада и Kaizen у основи су повећања перформанси процеса, као другог нивоа унапређења процеса у границама постојећих ограничења. Примена ових техника на другом нивоу теорије ограничења омогућава идентификовање шанси за повећање throughput-a, редуковање одступања од стандарда, брзо реаговање на проблеме које изазивају ограничења, успостављање континуираног тока свих процеса и подстицање запослених да раде као тим. Трећи ниво унапређења процеса у концепту теорије ограничења захтева преиспитивање свих активности које се одвијају у предузећу ради спречавања непотребног трошења ресурса. Технике успостављања тока материјала и синхронизације рада, које развија lean концепт су незаобилазна подршка на том нивоу. Ублажавање негативних ефеката постојећих ограничења и изналажење начина за њихов правазилажење у основи је четвртог нивоа теорије ограничења. Спречавање настанка грешака и могућих застоја, као и стварање услова да до машина дођу само квалитетни делови омогућава примена Jidoka и Poka-Yoka, и то прва у раним, а друга у каснијим фазама производног процеса. Несметано одвијање производног процеса подразумева активно одржавање машина и опреме где је неопходна помоћ технике тотално продуктивно одржавање. Брзу трансформацију целокупног производног процеса подржава SMED техника. Провера ефеката ублажавања ограничења одвија се на петом нивоу унапређења процеса у концепту теорије ограничења. На овом нивоу неопходно је вратити се на почетак и сагледати унапређење кроз све нивое уз проверу примене техника lean концепта.