Strategies of Effective and Reactive Supply Chains

Jacek Rudnicki
Wrocław University of Technology, Poland

The article deals with the analysis and assessment of lean strategy as well as of Six Sigma and the Theory of Constraints applied in effective supply chain management. These concepts were found mutually complementary. Agile strategy, as well as its comparative assessment with lean strategy, were analyzed. Agile strategy's aspects of development in reactive supply chain management were discussed. Three kinds of supply chain processes and the corresponding strategies such as lean, agile and lean-agile were singled out. The article established that effective and efficient supply chain management based on agile strategy is conditioned by the preceding both geographically and chronologically lean processes implementation.
Keywords: Lean Strategy, Six Sigma, the Theory of Constraints, Agile Strategy, Supply Chain Management

1. INTRODUCTION

Modern economy is characterized by competing supply chains, and not individual companies, moreover, a particular supply chain success or failure on the market is determined by the end consumer. Providing a consumer with the right product, at the right price, at the right time is not only a basis for gaining a competitive advantage, but a key to survive as well. Consumer satisfaction and the market comprehension are thus crucial elements to be considered when setting out a supply chain strategy. A supply chain participant can develop a strategy reconciling both the supply chain and the end consumer's needs only when the market restrictions are recognized and understood. It's an imperative for adjusting availability to current consumer needs which are a distinctive feature of modern economy. A supply chain can compete on the modern market subject to rapid changes owing to its ability to make available the right product, at the right price, at the right place.

A supply chain can compete depending on different criteria. Understanding the consumer segment needs that a supply chain is to satisfy leads to the competitive criteria identification. When identified, these criteria are a basis for accepting a common strategy for all the participants of a particular supply chain. Wrong identification of the competitive criteria by at least one participant of a particular supply chain and its implications referred to a particular product mean that the supply chain will compete less effectively.

We can list two major types of supply chains and their characteristic strategies that have different operational implications [15]:

- Effective supply chains
- Reactive supply chains

Effective supply chains will be characteristic of products with relatively stable long-term demand, long life cycle and high production volume called commodities products. Quality, lead time, reliability and availability will be the qualifying criteria for such products and first of all the price will be the order-winning criteria.

Reactive supply chains will be characteristic of products specific for a particular consumer with a high uncertainty of demand. Price, quality, lead time and availability will be the qualifying criteria

for such products and the level of service seen as ability to meet consumers' individualized expectations and requirements will be the order-winning criteria [10]. Because of that, reactive supply chains must be able to compete owing to their speedy reaction, flexibility and innovative products in rapidly-changing and individualized consumer needs' circumstances while keeping up effectiveness and profitability.

When selecting a supply chain strategy one must make it fit in with a competitive strategy aimed at a specific market segment and take into account the current and target company and supply chain development position.

Lean strategy of continuous efficiency improvement, as well as Six Sigma and the Theory of Constraints (TOC) concepts were included in the effective supply chain strategy and agile strategy was included in the reactive supply chain. Implementation of the strategies listed above doesn't exclude their effective and efficient use in the same supply chain.

The article's purpose is to point out the effectiveness and efficiency of simultaneous and complementary development of lean strategy alongside with Six Sigma and the TOC concepts in effective supply chain management, as well as of sequent both chronologically and geographically lean and agile strategies' development in reactive supply chain management.

2. LEAN STRATEGY IMPLEMENTATION IN EFFECTIVE SUPPLY CHAIN

2.1. LEAN STRATEGY

Lean strategy aims to eliminate waste in a supply chain while all the non-adding value activities are considered the waste. The term 'lean' was first introduced in 1990 by James Womack in the book: „The Machine that Changed the World" [1]. Lean strategy was designed in the 1950s in Toyota company and this company is the global leader in the strategy effective and efficient implementation until the present day.

Lean strategy focuses on eliminating waste in all the supply chain processes including relationship with the consumer, product development, manufacturing and supply. The goal is to produce as effectively as one can the right products of the right quality, at the right time and place, in the right quantities using less human resources, less inventory, less space and less time. Womack and Jones, in their subsequent book "Lean Thinking" [2], showed using the example of Coca-Cola tin supply chain that supply chains contain enormous waste and effectiveness reserves. The period of time for products to be brought from raw materials to the end customer is about 11 months and only 3 hours from that period include value-adding activities. The same authors described lean strategy implementation and Lean Thinking concept in supply chain management in the book "Seeing the Whole" [3].

Lean strategy implementation both in a company and in a supply chain consists of five phases, the so-called 'lean loop':

1. Specifying value from the end customer's perspective. The value is defined through consumer needs and expectations.
2. Identifying the value stream and waste in that stream. A value stream mapping method is used in order to find out which activities do not add value and must be eliminated.
3. Introducing the continuous and balanced flow in the value stream.
4. Introducing the principle of consumer-pull value.
5. Introducing continuous improvement. Waste elimination requires employees' engagement and carrying out projects of continuous improvement.

The process of the lean supply chain creation consists of the further lean loop iterations and the value stream mapping method is used during that process [3], [4].

Lean strategy means total, gradual and continuous elimination of waste in the supply chain and engaging all the employees. In a company, lean is implemented through a series of oriented mini-projects called *Kaizen blitz* carried out during a few weeks, in addition to which the processes are dealt with holistically and systemically [5].

2.2. SIX SIGMA

The Six Sigma concept was introduced at Motorola in the mid-80s of the past century. Six Sigma's key aim is to eliminate defects, that is

variations in processes to such a degree that Six Sigma variation (99,9997%) will not exceed the limit set by the consumer. It means that Six Sigma aims at non-defective processes and products (3.4 or less defective items or processes per million opportunities). Defects can refer to any aspect of consumer satisfaction, as for example: high quality of the product, conformity to the schedule or timeliness.

The Six Sigma concept presumes that everything is a process and variability is characteristic of all the processes. Statistical data are used to understand that variability and to make decisions during the improvement process.

Six Sigma is based on the following key principles:

- Focusing on the consumer: identifying consumer values is a starting point for all the improvement projects
- Orienting towards the processes: processes improvement is a way of building up competitive advantage in delivering value to consumers
- Decisions based on the relevant facts and data
- Standardizing and repeating
- Collaborating without boundaries: Six Sigma widens collaboration opportunities as the employees come to know their role in a value stream and measure the mutual dependence of all the activities in a process
- Tolerating errors: understanding the fact that no company achieved excellent results without mistakes

Six Sigma uses the DMAIC (Define, Measure, Analyze, Improve, Control) method of processes improvement called also Six Sigma loop:

1. **D (Define)** – defining the problem, localizing the area where the project is to be launched, specifying the goals and restrictions that are to be considered in order to get the higher sigma level
2. **M (Measure)** – gathering information on the process current state in order to figure out the reference level and the scope of the problem, selecting and verifying the system of the process measurement. Gathering data about the process.
3. **A (Analyse)** – seeking out the root causes of critical problems and confirming their impact on the process with the help of statistical data analysis
4. **I (Improve)** – introducing solutions that eliminate the root causes and critical problems earlier analyzed with the aim of bringing the process factors to the desired value
5. **C (Control)** – monitoring results achieved at the previous phase and controlling the process on the basis of those results. Keeping up the solutions.

Six Sigma is implemented in a company through numerous projects carried out according to the DMAIC methodology. Six Sigma projects are usually specified from a narrow perspective while the approach is effective in solving complicated problems that need probabilistic and statistic thinking. [5].

2.3. LEAN SIX SIGMA IMPLEMENTATION

In recent years companies have begun to recognize that implementing either lean or Six Sigma approach leads to serious restrictions. Lean ensures the process flow optimization, minimizes the flow time and makes the process less complicated. Six Sigma, in its turn, eliminates defects and variations thus making processes more reliable. That's why one can observe both approaches being more and more often applied simultaneously in a company. When those complementary approaches are being combined into what is called Lean Six Sigma companies can focus on the key competitive criteria such as speed, reliability and quality. For example, Six Sigma may be of use in supply chain projects when identifying variations and their root causes in delivery schedules and production processes, whilst the concept of waste elimination (lean) will lead to short lead time and low inventory (WIP) in meeting the market needs [6].

Companies that implement lean or Six Sigma approaches in most cases boast of very spectacular results at initial phases of development. And yet continuous and significant progress on the way to perfection turns to the period when the pace of improvement slows down and even to stagnation. Then the company usually decides to implement the additional strategy, for example lean or Six Sigma, and Lean Six Sigma programs and projects develop

simultaneously. Moreover, the order of the strategy implementation is important as far as the effectiveness of the process improvement is concerned. Having analyzed examples from the practice we can state that lean implementation should come ahead that of Six Sigma. It may be caused by the fact that lean strategy makes all the employees accept the waste elimination philosophy, that is elimination of non-value adding activities. So lean strategy introduces a company into the value stream continuous improvement and its competitive position improvement.

No matter what the order of strategy implementation is, some companies implementing lean, Six Sigma or Lean Six Sigma approaches find it difficult to carry out too numerous lean and Six Sigma programs and projects. Managers and other employees are overloaded with duties arising from their participation in several projects at the same time, having no opportunity to state which projects are important and which are not. If all the projects are of the highest priority it means that none of them has priority. It happens often that these improvement projects are considered from the point of view of the local optimization and a supply chain as the whole is not taken into account. Lean Six Sigma must be combined with the approach called the Theory of Constraints [6] in order to enable managers to find out the impact of the local initiatives on the whole supply chain.

2.4. THE THEORY OF CONSTRAINTS (TOC) APPLY IN SUPPLY CHAIN MANAGEMENT

The Theory of Constraints was worked out by Eliyahu Goldratt at the end of 70s of the past century. The TOC treats a company, or a supply chain, as a system. A system can be defined as a group of connected elements or processes that work together to transform input resources into output effects according to a specific goal. That goal is to earn money now and in the future. Throughput, that is the amount of money generated through sales, depends on the weakest chain link, or a system constraint [7]. The TOC points out two kinds of constraints:

- Physical constraint (internal or external)
- Constraint understood as the lack of strategic adjustment

The ability of a resource is usually a physical constraint. Market demand may also be a physical constraint. Lack of strategic adjustment will be a constraint if a competitive strategy is in conflict with the supply chain operational strategy.

The TOC presumes that concentrating on the weakest chain link, that is on a constraint, leads to the greatest benefit.

The TOC is based on five principles:

1. **Identify the system constraint**. Checking the chain supply symptoms can quickly help to identify the constraint.
2. **Maximize the constraint exploitation**. When the constraint localization is identified managers should maximize its work. For example, all the sources of waste and breaks in the chain link work must be eliminated in the chain link being the constraint.
3. **Subordinate all other processes to maximizing the constraint exploitation.** It's very important to understand that non-constraint resources work only to support the constraint. When, for example, a supply chain link is the constraint, all the other resources must produce and deliver at the same pace, which makes up for the constraint.
4. **Eliminate the constraint.** Managers should do their best to brake the constraint. It will be, for example, increasing the ability of a resource being the constraint, stimulating demand through the service level improvement, or policy change. Additional equipment, people and capital investments may be needed in order to brake the constraint.
5. **Return to Step 1 to keep inertia from becoming the constraint**. When the former constraint is broken in Step 4, a new constraint will appear in some other point of a supply chain. That's why it's necessary to identify the new constraint localization and to redirect the improvement activities there. For example, system productivity can be increased to such a degree that the market demand will become the constraint, so the improvement activities must be refocused on increasing the sales.

The presented above constraint management loop contributes to development of continuous improvement process. It's caused by the fact that a

company, or a supply chain, always have a new constraint. Lean Six Sigma projects and improvement initiatives should be assessed and prioritized according to their impact on the current constraint. For example, if it's productivity of a supply chain link that is the constraint, then lean tools must be used to eliminate waste and improve the flow. If the constraint is external and a company has higher productivity than the demand, then Six Sigma projects must deal with the demand stimulation through quality, speed and reliability [6].

A perfect analysis and assessment of the three concepts (lean, Six Sigma, the TOC) showed that they are complementary and don't exclude one another in supply chain management. The TOC is a system concept of projects and initiatives orientation that allows to focus on the right problem and the right solution, at the right time and the right place. Lean and Six Sigma tools and techniques may be applied that way wherever they will work to the greatest advantage while eliminating waste and reducing variations in the supply chain constraint.

3. AGILE STRATEGY DEVELOPMENT IN REACTIVE SUPPLY CHAIN

Lean strategy aims at the current processes improvement through continuous waste elimination. There is a continuous flow of similar products family taking place at a specific scheduled level in lean processes and the quantities of separate products can be subject to rapid and unlimited changes (practically at real time) depending on demand. A steady and balanced flow is attained owing to implementation of such control tools as hejunka and kanban (supermarket) [4], [8]. Lean processes have high quantitative flexibility but they are restricted to the defined and limited company offer as well as the planned level of aggregated production. Nonetheless, lean strategy is not a pro-flexibility strategy oriented at producing and delivering individualized products specific for a particular consumer. Putting it simpler, we can explain that by the fact that developing flexibility and ability to change is in conflict with simultaneous continuous waste elimination and cost reduction.

Lean strategy can be successfully applied in the environment of products with stable and more predictable aggregated demand. Yet, if a company and a supply chain want to satisfy consumers looking for special products that meet their individual needs and tastes then the demand will be less predictable and the lean strategy apply will be less effective for focus on waste elimination leads to restrictions and fixed supply chain processes. In the circumstances of great uncertainty of demand typical of specific products for a particular consumer the company should develop agile strategy which is more flexible in supply and demand adjustment.

Agile strategy (called also Agile Production, Agile Manufacturing, Agile Enterprise) was defined in 1991 when a group of managers from 13 American companies declared that only companies with agile production can be a success under the circumstances of continuous and unpredictable changes. According to experts taking part in that forum, companies striving to be a success in the 21th century must be agile that is able to respond quickly to continuous changes and they must have an evolving quality definition and a growing responsibility for the environment.

Agility is achieved through integration of the organization and the supply chain, highly qualified, empowered and trained employees, as well as advanced cooperation and innovation technologies aimed at providing consumers with high-quality individualized products [9],[13].

The purpose of agile manufacturing is to develop network and virtual organization, as well as to build up knowledge about the market in order to take advantage of rapidly changing market, which means advanced information technology is essentially needed here.

Agile enterprise structures base on groups working in modules characterized by their openness to innovation, flexibility and quick adaptation to new products and activities. Agile production is characterized by flexibility and the ability to respond quickly to technology and fashionable trends' changes, as well as quantity fluctuations.

Individualized mass production and distribution called also specific production for a particular consumer or mass customized production are the key elements of agile manufacturing. Processes flexibility needed for individualized production is achieved through small process units built on the modules basis that have short lead time, can adapt easily and make independent decisions about how to

divide the work. A network facilitating the integration of a consumer or a seller with a producer must be created in order to ensure the direct flow of information from consumer to production.

In order to effectively sell individualized production a system combining different modules or clusters must be as in the following characteristics [13]:

Rapid

Modules and processes must be combined very rapidly. It ensures prompt respond to different consumer needs.

Cheap

The combination must not increase significantly the processes cost.

Smooth

Consumers must not sense combinations and individual modules so that consumer service does not suffer damage. All the modules must act as the one.

Easy

Networks or module groups must be formed at low additional costs. On combining, the communication must function at once, without wasting time on building groups.

Dynamic and flexible agile processes that react quickly and effectively to the changing market and consumer needs can be projected and implemented in supply chains with such characteristics.

In order to work out the right supply chain strategy the company should specify the consumer segment needs that a supply chain is to meet, as well as the current and the target level of supply chain development. Three levels of supply chain development are presented below:

- Mass production supply chain
- Lean processes supply chain
- Agile processes supply chain

The corresponding strategies must be undertaken and carried out in order to achieve particular levels. (compare Figure 1).

When a company undertakes a new product manufacturing it aims at achieving a scale effect through mass production development. Then it implements lean strategy and tries to improve the competitive level through lean supply chain implementation.

Lean strategy leading to continuous waste elimination and developing value stream with a steady flow level will be typical of the development of competitive environment for commodities products. The level of flow for those products can be scheduled indispensably for lean supply chain owing to their predictable demand.

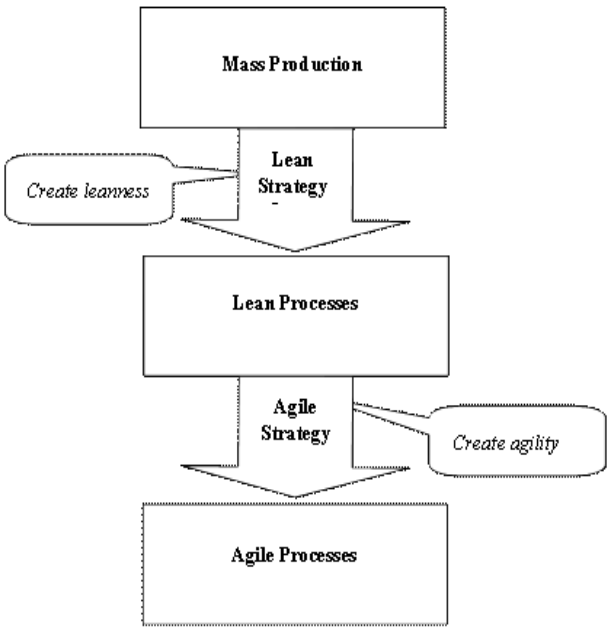

Figure 1. Phases of Agile Processes Achievement (source: self-designed)

When the supply chain achieves owing to lean strategy the desired competitive level of quality, reliability, lead time and costs, the company can, while developing agile strategy, transform selected processes and implement agile supply chain to enable products specific for a particular consumer compete on the market.

It should be mentioned that what is the waste in lean strategy, may be the asset in agile strategy. The issue of production capacity may be an example here. In lean manufacturing a consumer buys definite products generated in processes with balanced production capacity with an overload whilst in agile manufacturing the production

capacity is reserved for a consumer for it may be additionally needed in no time [10].

Successful agile processes implementation in a supply chain is determined by the previous lean processes implementation in the same supply chain. The agile process in the supply chain will be successful and effective on condition that it is fully understood, documented and projected. It will be possible when the lean process have been projected and built up and then adapted owing to elimination of production capacity definite impediments and limitations.

Lean strategy development in the whole supply chain leads to lean supply chain creation (see I of Fig. 2). Agile strategy development, in its turn, aims to attain agile supply chain (see II of Fig.2).

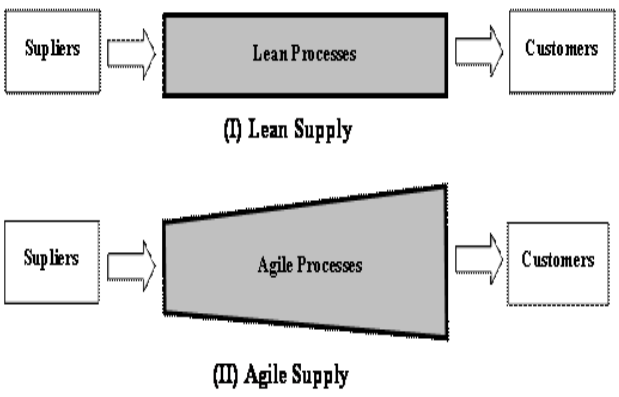

Figure 2. Lean and Agile Supply Chain Concepts (source: adaptation based on [10])

Supply chains combining both lean and agile processes will appear in practice, notwithstanding the fact that lean and agile strategies can't be *applied* simultaneously with regard to the same processes and products (see (III) of Fig. 3).

Lean-agile supply chain development is based on specifying the *Order Decoupling Point* (ODP), that is customer order penetration point, and moving lean processes upstream the supply chain and agile processes downstream the supply chain. Lean-agile supply chain concept helps to develop processes with high productivity and low costs that geographically precede reactive processes ensuring high level of individualization, differentiation and rapid respond to consumer specific needs.

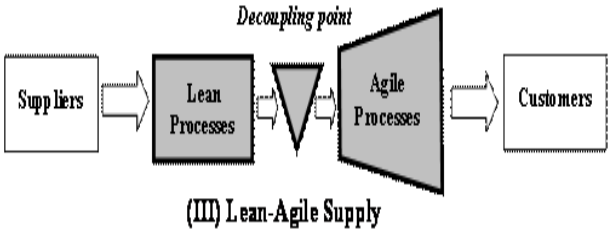

Figure 3. Lean-agile Supply Chain Concept (source: adaptation based on [10])

Lean-agile concept is closely connected to *postponement*, or the concept of postponing the product individualist ion, often because of moving the ODP in the supply chain [14]. Moving differentiation towards the consumer, which is equal to moving the order decoupling point, contributes significantly to lean-agile reactive supply chain effectiveness owing to enlarging the scope of effective supply chain with lean processes. For example, the regional differentiation postponement until the moment the products have regional distribution centers increases regional individualization effectiveness in packing, labeling, adding documentation and preparing the augmented product. And production for a specific consumer is possible owing to the differentiation postponement until the moment the orders are accepted. The *postponement* concept apply increases reactive supply chain effectiveness while attaining the competitive level of service of consumers from the market segment the supply chain is oriented at.

4. SUMMARY

In the era of competing supply chains the supply chain success is conditioned by the right strategy development. The strategy selection depends on the level of product individualization, level of the demand uncertainty related to it, as well as the current and target position in supply chain development. The article proves that lean strategy is a leading operative strategy conditioning effective and efficient management of both effective and reactive supply chains. In the case of effective supply chains lean strategy implementation ensures the state of continuous supply chain processes improvement through waste elimination. It was also established that complementary and simultaneous Six Sigma and the TOC apply can increase significantly the effectiveness and efficiency of lean strategy development. In the case of reactive supply

chains the preceding both chronologically and geographically lean strategy development conditions the effectiveness and efficiency of the agile strategy and the mass individualization concept.

BIBLIOGRAPHY

[1] Womack, J.P., Jones, D.T.,and Ross D., *The Machine That Changed the World*, Harper Perennial 1990

[2] Womack, J.P., Jones, D.T., *Lean Thinking,* Simon & Schuster, New York 1996

[3] Womack, J.P., Jones, D.T.,*Seeing the Whole (Polish) ,* The Lean Enterprise Institute, 2009

[4] Rother, M., Shook, J., *Learning to See (Polish)*, The Lean Enterprise Institute, WCT, Wrocław 2003

[5] Jugulum R., Samuel P., Design for Lean Six Sigma, John Wiley&Sons, New Jersey, 2008

[6] Spector, R.,E., *How Constraints Management Enhances Lean and Six Sigma*, Supply Chain Management Review, January/February 2006

[7] Goldratt, E., *The Goal*, North River Press, Great Barrington, Messachusetts, 1992

[8] Liker, J.,K., *The Toyota Way*, New York, McGraw-Hill, 2004

[9] Kidd Paul T., *Agile Manufacturing,* Addison-Wesley Publishing Company, 1994

[10] Mason-Jones, R., Naylor, B., Towill, D., *Lean, agile or leagile? Matching your supply chain to ...,* International. Journal of Production Research, Voll 38, Nov., 2000

[11] Steinbeck H.,H., *Total Quality Management,* Agencja Wyd. Placet, Warszawa 1998

[12] Rudnicki J., *Strategia agile w zarządzaniu łańcuchem dostaw*, Komputerowo zintegrowane zarządzanie. Tom II. WNT, Warszawa 2003, str. 349 – 356.

[13] Pine, J., B. II, Boynton A., *Making Mass Customization,* Work, Harvard Business Reviev 71, no. 5 (1993)

[14] Harrison A., van Hoek Remko, *Logistics Management and Strategy*, Prentice Hall, 2002

[15] Chopra S., Meindl P., *Supply Chain Management*, Prentice Hall, New Jersey, 2001