July 2012

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Recommended Citation

Jauhar, Sunil; Tillasi, Piyush; and Choudhary, Rachana (2012) "Integrating Lean Six Sigma and Supply Chain Practices for Improving the Supply Chain Performance," *Undergraduate Academic Research Journal*: Vol. 1 : Iss. 1 , Article 17.

DOI: 10.47893/UARJ.2012.1016

Available at: <https://www.interscience.in/uarj/vol1/iss1/17>

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Integrating Lean Six Sigma and Supply Chain Practices for Improving the Supply Chain Performance

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Abstract - This paper describes the fusion of Lean and Six Sigma is required to achieve the fastest rate of improvement in quality, cost, delivery and process speed. By combining Lean and Six Sigma it is possible to achieve highly effective improvements in a company's operations. Six Sigma doesn't focus on speed. And, Lean cannot bring a process under statistical control. Lean Six Sigma efforts tend to be aligned by organizational functions rather than supply chains. This can result in departmental improvements, but fall short in achieving end to end supply chain improvements. Supply chain management (SCM) is a major issue in many industries as organizations begin to appreciate the criticality of creating an integrated relationship with their suppliers and customers, as well as all other stakeholders. It is concerned with smoothness, economically driven operations and maximizing value for the end customer through quality delivery. Hence, research is undertaken to integrate lean Six Sigma and SCM that will focus on how their integration drives rapid focused product and process improvements which result in controlled, sustainable, and validated improvements to the bottom line.

Keywords - Lean, Six Sigma, Lean Six Sigma, Supply chain management, supply chain performance.

I. INTRODUCTION

1.1 Supply chain management

As product life cycle shrank and global competition intensified in the 1990s, many manufacturers collaborated with their suppliers to improve product quality and lead time. Accordingly, many wholesalers, distributors, and retailers also integrated their logistics activities to achieve competitive advantage. Eventually, these two major functional areas of the manufacturing organizations evolved and merged into a holistic and strategic approach to materials and logistics management. Many buzzwords such as supply base management, supply chain synchronization, supplier integration, partnerships, etc. can be found in the literature to address the elements of this new management philosophy. The term supply chain management (SCM) is most widely used to represent this area of business management (Tan *et al.*, 2002). Despite its popular applications, there is dearth of an explicit and commonly agreed standard set of specific activities and practices, and the way in which SCM impacts the performance of the organization as a whole. However, as pointed by Christopher (1992), it has been immensely emphasized among the researchers and

professionals that organizations will not seek to achieve cost reductions or profit improvement at the expense of their supply chain partners, but rather seek to make the supply chain as a whole more competitive. In short, the argument that it is supply chains, and not individual firms, that compete is at central focus in the field of supply chain management.

1.2 Supply Chain Performance

1.2.1 Significance of Performance Evaluation

Performance evaluation is a strategic tool that provides means to achieve the objectives and fulfilling organization's mission. As highlighted in the earlier section, major task in performance measurement is to identify, evaluate and select the performance measures, which are appropriate to assess inter-organizational performance. A general tendency in many firms has been to measure performance, primarily on the basis of cost and efficiency (Skinner, 1971). This has resulted in most measures focusing on financial data such as return on investment, return on sales, price variances, sales per employee, productivity and profit per unit production etc. To succeed in these conditions, Kanter (1995) suggests that organizations need abundant stocks of three global assets of concepts, competence, and

connections, which derive from investments in innovation, learning, and collaboration. Also, Tincer (1994) argues that world class organizations have to practice some crucial strategies and policies in response to the challenge of global competition. One such critical policy is performance evaluation incorporating non-financial performance measures (Sheridan, 1990). With the emergence of global competition since the late 1980s performance measurement has become very relevant with ever-increasing interest in the subject.

As discussed earlier in the introduction, the impact of global competition in the current business environment has imposed considerable changes in the way organizations function and therefore, created changes in the nature of work by adopting new management practices, for example JIT, TQM, and SCM, which are targeted at performance improvement. Changing customer demands, quality awareness and growing advances in information and communication technology (ICT) have also led to substantial changes in the market places. In line with above reasons, Dangayach and Deshmukh (2001) argue that, performance evaluation is required to have a strategic input to the above issues. Neely *et al.* (1995) explained performance evaluation as the process of quantifying the efficiency and effectiveness of action; they defined performance measure as 'a metric used to quantify the efficiency and effectiveness of an action'. There are other definitions for performance measurement such as the one provided by Marshall *et al.* (1999), who define performance measurement as the 'development of indicators and collection of data to describe, report on and analyze performance'.

1.3 Supply Chain Performance Measures

Performance measurement is very important as a strategic tool and also provides means to achieve the objectives required, fulfilling a firm's mission/strategy statement. Many firms have been observed to evaluate performance, primarily on the basis of cost and efficiency (Skinner, 1971). Therefore, traditional performance measures have been primarily based on management accounting systems and financial measures (Alaa and James, 1996). This has resulted in most measures focusing on financial data such as return on investment, return on sales, price variances, sales per employee, productivity and profit per unit production etc. As a result of globalization and competition the organizations have started adopting innovative business practices and performance improvement initiatives such as TQM, JIT and SCM. The traditional cost-based measures are found to be inadequate as they fail to incorporate the basic principles of continuous improvement and intangible aspects of performance. Therefore, firms can't manage properly if they can't

measure the intangible and non-financial performance also. And hence, performance measurement incorporating non-financial measures has been a topic of great interest throughout most of the 1990s.

Performance Measure	Goal	Purpose
Resource	Efficiency	Efficient resource management is critical to profitability
Output	Customer service	Without acceptable output, customers will turn to other supply chains
Flexibility	Ability to respond	Firm's competitiveness and market sustainability

1.3.1 Supply Chain Resource Performance:

Resource measures are concerned with the efficiency in using the resources in a supply chain system. Resource measures include-

- ✓ total costs of resources used,
- ✓ Total costs of manufacturing (labour, maintenance, re-work costs etc.),
- ✓ total costs of distribution,
- ✓ The return on investments.

1.3.2 Supply Chain Output Performance:

Output performance measures not only correspond to the organization's strategic goals, but must also correspond to the customers' goals and values. Output measures include customer satisfaction in terms of

- ✓ on-time deliveries (Measures item, order, or product delivery performance)
- ✓ order fill rate (Proportion of orders filled immediately)
- ✓ customer response time (Amount of time between an order and its corresponding delivery), and
- ✓ annual sales,
- ✓ Manufacturing lead time (Total amount of time required to produce a particular item or batch).

1.3.3 Supply Chain Flexibility Performance:

Ability to adjust and accommodate the favorable changes in the business environment. system's ability to accommodate volume and schedule fluctuations from suppliers, distributors, and customers. Ability to respond to and accommodate-

- ✓ Demand variations, such as seasonality.
- ✓ Periods of poor manufacturing performance (machine breakdowns)
- ✓ Periods of poor supplier performance.
- ✓ Periods of poor delivery performance

1.4 Six Sigma

Six Sigma is a highly technical method used by engineers and statisticians to fine tune products and processes. It is a goal of near perfection in meeting customer requirements. It was originated in Motorola in 1987. In 1994, Larry Bossidy, CEO of Allied Signal, introduced Six Sigma as a business initiative target to produce high level results, improve work processes and improve employees' skills. Though Six Sigma was originally developed for manufacturing processes, many service industries like telecom, hospitals, banking etc. are using Six Sigma to improve profits and performance. Major problems in marketing, finance, information systems, and human resources are solved by using Six Sigma. A cross-functional team is necessary to implement Six Sigma programs and the purpose of the team is to provide an on-going involvement of management in the implementation process [1].

Six Sigma is a comprehensive and flexible system for achieving, sustaining and maximizing business success. Six Sigma philosophy is used to identify and remove the causes of defects and errors in manufacturing and supplies using a standard DMAIC viz. Define, Measure, Analyze, Improve and Control approach, which strive for achieving target of 3.4. DPMO i.e. Defects Per Million Opportunity. It is uniquely driven by close understanding of customer needs, disciplined use of facts, data, and statistical analysis, for managing, improving and reinventing business processes. Thus, Six Sigma plays an important role in cost reduction, productivity improvement, market share growth, customer retention, cycle time reduction, defect reduction, product / service deployment and last but not least important, the cultural change. Six Sigma executives i.e. Black belts and champions view Six Sigma as an approach that leads to competitive advantage.

Six Sigma is generally mastered by Black Belts by rigorous four weeks training. Black belts need necessary

support by top executive i.e. a champion, to improve the pace of improvement ahead of the competitors. In spite of breakthrough results in defect reduction by Six Sigma, it had been identified that Six Sigma cannot improve the process speed. While, Lean cannot alone bring the process under statistical control. Hence, Lean Six Sigma, fusion of Lean and Six Sigma is recommended to improve the speed and defect prevention [2]. Integration of Lean Six Sigma with Supply Chain Management (SCM) is suggested to improve the competitiveness of entire supply chain. Literature review revealed that less research is done on integration of Lean Six Sigma and SCM. Hence, a model is proposed which will minimize limitations of Lean, Six Sigma and SCM. Integrating Lean Six Sigma and Supply Chain Management for Improving the Supply chain Performance

II. LITERATURE REVIEW

2.1 Supply Chain Performance Measures

Based on the extant literature, numerous processes have been developed that organizations can follow in order to design and implement performance evaluation and measurement systems (Bourne *et al.*, 2000). Many frameworks supporting these processes have been proposed to help organizations define a set of measures that reflect their objectives and assess their performance appropriately. These include the balanced scorecard (Kaplan and Norton, 1992), the performance prism (Kennerley and Neely, 2000), the performance measurement matrix (Keegan *et al.*, 1989), the SMART pyramid (Cross and Lynch, 1989), and the results and determinants framework (Fitzgerald *et al.*, 1991). Some of these frameworks are multidimensional, explicitly balancing financial and non-financial measures. Furthermore, a wide range of criteria has also been developed, indicating the traits of effective performance measures and measurement systems. These include the need for measures to relate to the organization's mission and objectives, to reflect the company's external competitive environment, customer requirements and internal objectives (Wisner and Fawcett, 1991; Kaplan and Norton, 1993). Wisner and Fawcett (1991) acknowledge the need to review and update the performance measures to ensure that measures remain relevant. Bititci *et al.* (2005) identify the need for performance measurement systems to be dynamic to reflect changes in current competitive environment, review and prioritize objectives, and ensure gains achieved through improvement programme's are maintained. Significant contributions for supply chain performance measures are shown in Table 1.1,

Table 1.1: Significant Contributions for Supply Chain Performance Measures

Experts	Performance Measures
Neely <i>et al.</i> (1995), Beamon (1999), Cohen and Lee (1989), Cohen and Moon (1990), Pyke and Cohen (1993, 1994)	Cost
Davis (1993), Newhart <i>et al.</i> (1993), Towill <i>et al.</i> (1992),	Customer responsiveness
Wikner <i>et al.</i> (1991), Lee and Bellington, (1993)	Flexibility
Voudouris, (1996)	Customer satisfaction Supplier performance Risk management Information flow
Christopher, (1994)	
Davis, (1993)	
Johnson and Randolph, (1995)	
Nicoll, (1994)	

Dan Swartwood [3], stated that by combining Lean and Six Sigma, it is possible to achieve highly effective improvements in a company's operations. There are, however, two major weaknesses in this approach. First, the project selection process is not well defined. It does not require the company to methodically select, rank, and assign projects, but usually relies on more subjective methods. Projects may or may not be aligned with the corporate business strategy and goals. Second, Lean Six Sigma efforts tend to be aligned by organizational functions rather than by supply chains. This can result in departmental improvements, but fall short in achieving end-to end supply chain improvements. Since Lean Six Sigma depends primarily on brainstorming for project ideas, it can be difficult to sustain long term momentum once the initial waves of projects are complete. Brainstorming will identify the most obvious issues, but eventually runs out of steam. He proposed SCOR as a cross-industry model designed to analyze a supply chain and identify improvement opportunities in both Material flow and Work & Information flow. The SCOR model defines a supply chain as, "The integrated processes of Plan, Source, Make, Deliver and Return, spanning your supplier's supplier to your customer's customer, aligned with Operational Strategy, Material, Work & Information Flows." The SCOR model is implemented in phases, starting at a high level usually Enterprise or Supply Chain and progressing down to Material flow and Work & Information flow activities.

S. Chakravorty and Hales [4] described a successful lean implementation plan to successfully orchestrate activities related to the implementation. The plan should include a sequence of execution activities including lower level team improvement exercises, a training schedule, and a detailed plan of all necessary changes related to the implementation. The plan provided a basis for implementation, documentation, and revisions needed to assure continuous improvement. Hendry and Nonthaleerak [5], commented that traditional quality concepts like Statistical Quality Control (SQC), Statistical Process Control (SPC), Zero Defects and

Total Quality Management (TQM), have been major tools for many years; While Six Sigma is a more recent initiative quality improvement to gain popularity and acceptance in many manufacturing and service industries across the world.

As Mullavey [6] points out, in order to successfully implement Six Sigma programs, management must understand Six Sigma methodology, provide leadership, and must guide the implementation process. According to Keller [7], Six Sigma programs have many tools for improvement, which include Histograms, Pareto Charts, Statistical Process Control (SPC), and Analysis of Variance (ANOVA). Lee-Mortimer[8] considered the DMAIC methodology to be essential to Six Sigma programs and appropriate for delivering business improvements.

Kwak and Anbari [9] summaries Six Sigma as a strategy which includes TQM, strong customer focus, additional data analysis tools, financial results and project management to satisfy customer needs. Six Sigma's DMAIC Viz. Define, Measure, Analyse, Improve and Control is similar to Deming's PDCA i.e. Plan, Do, Check, Act cycle. They further concluded that Six Sigma is rapidly becoming a major driving force for many technologies driven, project driven organizations. Factors influencing successful Six Sigma projects include management involvement and organizational commitment, project management and control skills, cultural change and continuous training.

Soković [10], described Six sigma as an effective way to find out where are the greatest process needs and which are the softest points of the process. According to him, Six sigma provides measurable indicators and adequate data for analytical analysis. It is a powerful methodology that results with significance savings and improvements, if properly implemented. Tools and methodology within Six Sigma deal with overall costs of quality, increasing overall quality level contribute to company business success and profitability. In accordance with Six Sigma DMAIC methodology, project goals should be defined, cross-functional teams formed including individuals with adequate process knowledge, historical information collected, and appropriate process selected for improvements. According to Banuelas [11], the prioritization of projects is determined by many criteria, such as a cost benefit analysis or the Pareto priority index. Research carried out by Kevin Linderman et.al. [12] Investigated the tension between goals and Quality management in the Six Sigma context. They found that goals can be effective in Six Sigma improvement teams when teams adhere to Six Sigma tools and method. However, challenging goals are counterproductive when Six

Sigma teams do not use the tools and methods rigorously.

Foster [13] claimed that a common process for implementing improvement tools is the DMAIC methodology, which is similar to Edward Deming's "Plan-Do- Check-Act" problem solving approach. Mast and Bisgaard [14] considered DMAIC methodology as the scientific method in Six Sigma programs. Study carried out by Sanjay Goel and Vicki Chen [15], showed how large global corporations with multiple sites can accomplish reengineering efficiently through a structured methodological approach. The study highlighted the reengineering process based on a repertoire of Six Sigma tools used at General Electric employing statistical analysis to track the quality and performance of individual components of a process, product or service. Schroeder et al. [16] identified five elements of these programs i.e. management's involvement, training of improvement specialists, performance metrics and measurements based on cost, quality, and schedules, systematic five-step DMAIC methodology and project selection and prioritization. Further, Schroeder and team differentiated between TQM and Six Sigma and highlighted the use of specific metrics in Six Sigma.

S. Thomas Foster Jr. [17] defined Supply Chain Quality Management (SCQM) as a systems based approach to performance improvement that leverage opportunities created by upstream and downstream linkages with suppliers and customers. While briefing about current research in SCQM, S. Thomas surveyed about the research carried out by Kaynak and Yeung, Sroufe and Curkovic, Das, and Schroeder. He identified key quality management content variables such as customer focus, quality practices, supplier relations, leadership, HR practices, business results and business safety. He concluded that SCQM is an important emerging area that needs to be further researched.

Kaynak and Hartley developed a structural equation model showing the relationships between quality management practices and upstream and downstream entities in the supply chain. They studied how these two upstream and downstream practices influence quality-related performance and examined eight QM practices viz. management leadership, training, employee relations, customer focus, quality data and reporting, supplier quality management, product or service design, and process management. Yeung investigated the impact of SSM (strategic supply management) on organizational performance in the form of efficiency, customer satisfaction and business outcomes. Sroufe and Curkovic laid the foundations for research propositions to build theory in quality assurance and SCM. They demonstrated that ISO 9000:2000 was

created to address shortcomings of ISO 9000 as the latter was unable to deliver real benefits and continued over-emphasis on bureaucratic procedures and documents. The research carried out by Das and team linked safety and quality performance which has not been studied in supply chain literature. Schroeder commented that Six Sigma is similar to TQM, but still it should not be dismissed as "nothing new."

Integrating Lean Six Sigma and Supply Chain Management for Improving the Performance 479 Gopal [18] highlighted that lack of commitment from management was the major reason behind failure of Six Sigma implementation in many companies. Management simply pushed Six Sigma programs out to employees, and did not become personally involved in the implementation process. Xingxing Zu [19] and team used a large scale survey to test Six Sigma role structure, Six Sigma structured improvement procedure and Six Sigma focus on matrices and their relationships with traditional quality management practices and found empirical support and performance improvement which can provide a basis for more research on Six Sigma. According to Schroeder [20], scholarly definition of Six Sigma is, "an organized, parallel meso structure to reduce variation, in organizational processes by using improvement specialists, a structured method, and performance metrics with the aim of achieving strategic objectives". In general, Six Sigma can be considered as an extension of other quality improvement tools such as Deming's statistical quality control and Total Quality Management (TQM).

According to Chakravorty and Franza [21], a form of DMAIC methodology, Define- Measure-Analyze-Design-Verify (DMADV), was central to a new product development experience. Satya S. Chakravorty [22], proposed six steps Six Sigma implementation model. The first step is to perform strategic analysis driven by the market and the customer. The second step is to establish a high-level, cross-functional team to drive the improvement initiative. The third step is to identify overall improvement tools. The fourth step is to perform high level process mapping and to prioritize improvement opportunities. The fifth step is to develop a detailed plan for low-level improvement teams, and the sixth step is to implement, document, and revise as needed.

Six Sigma provides a basic framework in which all these tools can be performed with management support. According to A. V. Todoruț [25], Lean Production means, in summary, five minimizations and five maximizations. The five minimizations refer to the minimization of material handling, minimization of distances, minimization of efforts, minimization of disorder and minimization of storage. The five

maximizations are: maximization of use, maximization of flexibility, maximization of the production flow, maximization of visibility and maximization of communication. Petcu Andreea [26] proposed Lean Six Sigma as a holistic management approach to continuous improvement for all the domains in which the organization operates. To move forward to further visions such as agility and total supply chain integration, organizations will need to act as Lean as possible, providing transparency for the implementation of Six Sigma methods and techniques.

Fig. 2: Limitations of Lean, Six Sigma and SCM

III. PROPOSED METHODOLOGY OF RESEARCH WORK

The literature review revealed lot of case studies of benefits by applying Six Sigma. Lean Six Sigma, comparatively recent tool, also has shown significant results in reducing the defects and improving the process speed. But, Very less research has been done on integrating Lean Six Sigma and SCM. Hence, proposed research is undertaken. The proposed research will be carried out in following steps.

After thorough literature review a case study will be performed in a company, preferably from manufacturing sector implementing Lean Six Sigma principles and ready for information sharing regarding SCM. Data collection from stakeholders like suppliers, their suppliers, and customers' etc. regarding material flow at different stages will be collected.

If required, competitive data will be obtained by Quality Function Deployment (QFD) matrix. Next step involves the analysis of material flow throughout the supply chain from suppliers through to customers. This analysis will help in identifying the projects needing the Lean Six Sigma application. The data related to the key elements in supply chain such as purchase orders, work orders, sales orders and planning events will lead to a work and information flow map. The effect of integrating three issues i.e. Lean Six Sigma and SCM

will be studied and analyzed. On the basis of case study, a questionnaire will be prepared discussing issues related to Lean, Six Sigma and SCM. Responses will be collected from stakeholders of various manufacturing firms such as suppliers, end suppliers, end users etc. either personally or through email. Responses will be analyzed using statistical tools and an attempt will be made to develop a generalized mathematical model. On the basis of survey and analysis, proposed recommendations to the small, medium and large scale manufacturing companies regarding integration of Lean Six Sigma and SCM may help in smoothening SCM operations and reduce the cost.

IV. DISCUSSIONS AND CONCLUSIONS

In this paper, we have discussed Six Sigma, Lean, Necessity of Lean Six Sigma and also SCM and its limitations. The thorough literature review is carried out on the topics Lean, Six Sigma and SCM. The review indicated the necessity of integrating SCM with Lean Six Sigma to overcome limitations of tools like Lean, Six Sigma and entire Supply Chain Management process. The proposed research will result in production of defect free products at a greater speed with smooth flow of materials from suppliers to manufacturers, manufacturers to distributors and to the end users may be through retailers, benefitting medium and large scale industries to a great extent.

Fig. 3: Integration of Lean, Six Sigma and Supply Chain

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