PAPER PUBLISHED IN

REVIEW OF BUSINESS AND ECONOMIC LITERATURE

S De Leeuw, L Gutierrez-Gutierrez, R Dubbers (2013): "An Integrative Model for Lean Six Sigma Implementation in Logistics Services Environments" *Review of Economics and Business Literature*, Vol.58, n.3, pp. 211-230

An integrative model for Lean Six Sigma implementation in logistics services environments

Abstract

Lean Six Sigma (LSS) constitutes a successful initiative for organizational improvement. Despite this success, literature does not include an integrative model for its organizational and practical implementation in logistics services environments. This paper fills this gap and proposes such an overall framework. At the present, logistics services play a fundamental role in supply chain management and organizational competiveness context. For these purposes, the paper carries out a literature review of peer reviewed journals related to LSS implementation and the logistics services context, which culminates in a proposed integrative model. Furthermore, associated with this model, a set of theoretical propositions are included. Finally, the paper discusses implications and lines for further research.

Keywords: Lean Six Sigma, logistics, implementation framework, supply chain, critical success factors

1. Introduction

Lean Six Sigma (LSS) is a continuous improvement (CI) methodology that maximizes the potential for improvement of organizations (Bhuiyan and Baghel, 2005; Taghizadegan, 2006). LSS comes from the fusion of Lean philosophy and the Six Sigma methodology. The Lean and Six Sigma methodologies have been integrated into this more powerful and effective hybrid, LSS, addressing many of the weaknesses and retaining most of the strengths of each strategy (Arnheiter and Maleyeff, 2005; Goldsby and Martichenko, 2005; Kumar et al., 2006; Wang and Chen, 2012).

Several positive effects of LSS have been recognized in literature. Through case studies, literature shows significant benefits associated to LSS, such as reduced costs and cycle times, improvements in customer returns and inventory, and increased production capacity (Pickrell et al., 2005), but also reduced time to process payroll, purchase and accounts payable (Furterer and Elshennawy, 2005). As a result, both the practitioners' and academics' interest in LSS is growing.

Even though LSS is being used widely, little research has been done to get a thorough understanding of the principles of this method and its applicability in different environments (Wang and Chen, 2012). Interesting studies in this field are done by Kumar et al. (2006) and Chen and Lyu (2009). Both articles developed an implementation framework to apply LSS to a manufacturing process. Nevertheless, the applicability of the developed frameworks to other processes of the same environment is missing. Kumar et al. (2006) and recently, Gnanaraj et al. (2012), concluded that in general there is no standard framework for LSS implementation. In addition to this, there is no clear understanding on the usage of tools and techniques within the LSS framework (Kumar et al., 2006; Wang and Chen, 2010). Consequently, there is the need to progress in this topic.

On the other hand, as Bhuiyan and Baghel (2005) concluded, there is a need for research in the field of the hybrid CI methodologies, like LSS, and to determine their applicability to various organizations. In fact, there is not a general agreement about the widespread applicability of CI methodologies (Tatham and Mackertich, 2003). According to Psychogios and Tsironis (2012, p.398) "…the main question for LSS is related to its liabilities and/or constraints regarding its implementation in different organisational and sector contexts”. In order to solve this, we focus in this paper on one specific environment: logistics services. CSCMP (2011) defines logistics management as “that part of supply chain management that plans, implements, and controls the efficient, effective forward and reverses flow and storage of goods, services and related information between the point of origin and the point of consumption in order to meet customers' requirements”. In our paper we will follow that definition.

In recent years logistics services and its broader context supply chain management have received increasing attention, from both academics and managers (Rahman, 2006). A common theme in services is that human labor is significant. Models from manufacturing are often not directly applicable to supply chain services (Ellram et al,. 2004).

In today’s global business environment, it is widely acknowledged that effective and efficient management of logistics and supply chain activities can provide a means of improving organizational performance (Chapman et al., 2003; Rahman, 2006), even gaining competitive advantage (Rahman, 2006). Due to this importance, for example, Goldsby and Martichenko (2005) offer a proposal for LSS implementation in logistics services. They focus on logistics flow, capability and discipline and provide a set of tools a logistician can select from. However, our research aims at the process of implementation of Lean Six Sigma in a logistics services environment. Our research therefore intends to develop a profound understanding of how Lean Six Sigma can be applied successfully in a logistics services environment.

The objectives of this research can be described by the following:

- Create a general understanding of how LSS could be used in logistic service environment.

- Develop an integrated implementation LSS framework for logistic service environments, with organizational as well as process application aspects.

The proposed framework is on the one hand focused on implementation and therefore useful for certain processes, but on the other hand it is also general in the sense that it can be used for the complete logistics service environment. With this framework the conceptual background of LSS will be extended to the field of logistics services environments, which will be the contribution to research in general. This paper also focuses at the formulation of a set of propositions supported by academic peer reviewed articles. These propositions constitute a significant theoretical contribution for future research. For practitioners the framework and propositions can lead to a thorough understanding of how to use LSS with its techniques and tools in logistics services environments.

The paper is structured as follows. The next section defines and describes the LSS methodology. The third section describes the logistics services environment, and consecutively we describe previous LSS implementation frameworks. The fifth section explains the proposed model for LSS implementation and associated propositions. The last section provides conclusions, implications for practitioners, limitations and avenues for further research.

2. Lean Six Sigma

As mentioned above, LSS can be defined as a continuous improvement methodology. For this purpose, LSS pursues to improve quality levels, reduce variation and eliminate waste. LSS results from an integration of the Lean philosophy and the Six Sigma methodology. Su et al. (2006) stated that Lean does not possess the tools to reduce variation and bring a process under statistical control, while Six Sigma views elimination of variation as essential. On the other hand, Six Sigma does not attempt to develop a theoretical or practical link between quality and speed; this is the area where Six Sigma falls short compared to what Lean can offer (Su et al., 2006). Thus, this integration leads to more significant benefits than those that each alternative could obtain separately (Arnheiter and Maleyeff, 2005; Bhuiyan and Baghel, 2005; Devane, 2004; Su et al., 2006; Wang and Chen, 2010; 2012).

The objectives of Lean Six Sigma are to rapidly improve customer satisfaction and quality, to increase processing speed[1] and reduce costs (Cheng and Chang, 2012). Furthermore, LSS increases employee's knowledge, resulting in product and delivery improvements (Taghizadegan, 2006). Table 1 summarizes the main characteristics of LSS.

Table 1. Overview characteristics of Lean Six Sigma

Methodology	**Lean Six Sigma**
Definition	A continuous improvement methodology which maximizes value added content and minimizes variation of quality and process characteristics, thereby improving customer satisfaction.
Focus	Total process (flow), problem focused, data driven, customer satisfaction, structured education, recognition of responsibility for quality of all employees and reduction of variability at every opportunity
Assumptions	Business will improve by removing waste, reduce variation in all processes and create a streamlined flow throughout the processes. People value the visual effect of the flow, figures and numbers. A problem exists and many small improvements are better than system analysis.
Output/benefits	Priority of process/product improvement can be set easier. Uniform product and process output. A total system approach which reduced the flow time and increase process capabilities. Provides a general analytic framework for problem solving, improve quality and an organizational infrastructure for education and creates performance measurement systems.

[1] Processing speed refers to the time required during the production and service processes. Processing speed allows small production lot sizes and less work-in-process inventory and will result in delivery and process flexibility improvements (Swink and Nair, 2007).

Based on Arnheiter and Maleyeff (2005), Bhuiyan and Baghel (2005) and Su et al., (2006).

3. The logistics services environment

In this paper, we propose a specific framework for LSS implementation in the logistics services environment. In order to better understand whether and how quality management approaches such as LSS affect organizations, it is important to study the organizational contexts in which these approaches are implemented (Sousa and Voss, 2002). For this reason, this section explains some specific features of this environment.

Firstly, in business, logistics services are integrated with purchasing, operations and marketing with the end customer as its prime focus (Fung and Wong, 1998). The main logistics services that are provided by third parties (LPS's) are, following CSCMP (2011), transportation, warehousing, cross-docking, inventory management, packaging, and freight forwarding. However, logistics services may include many more activities that pertain to the physical flow of goods or the related information flow: inbound and outbound transportation management, fleet management, warehousing, materials handling, order fulfilment, logistics network design, inventory management, supply/demand planning, management of third party logistics services providers, sourcing and procurement, production planning and scheduling, packaging and assembly, and customer service (CSCMP, 2011). Consequently, there is a significant amount of different activities in the logistics services sector.

Secondly, because of the relation with the product flow, these activities are all product-based and fall under the definition of manufacturing supply chains as given by Ellram et al. (2004). Ellram et al. (2004) argue that manufacturing supply chains have a movement of goods from suppliers to customers in common.

Finally, and related to the above, customer involvement in these activities is considerable. Logistics objectives are generally related to the reduction of complexity in order to make processes more efficient (Schramm-Klein and Morschett, 2006). One may therefore argue that the degree of customer input is not high. However, lean philosophy is clearly oriented to customers . This philosophy pursues to create open and honest business relationships with customers, building a customer-focused organization (Sohal and Egglestone, 1994; Worley and Doolen, 2006) For this purpose, information from customers is essential. This indicates the need for customer input and therefore creates a better understanding of the services aspect of logistics services. To provide a complete framework, we incorporate the customer's perspective explicitly in this paper.

The performance of logistics services may be measured through a concept called logistics service quality. Mentzer et al. (2001) established a conceptualization of logistic service quality as a process of nine interrelated quality aspects that are reliable and valid across customer segments. Table 2 explains the nine quality aspects and indicates if the 'process' needs customer input as 'supply'. These indications are made based on the definition of customer input made by Sampson (2006). Table 2 indicates that, to have measurements of most of the quality aspects, customer input is necessary. However, most of these measurements (probably except for 'personal contact quality' and 'information quality') are determined by the underlying logistics activities. For example, the logistic activity of inventory management will have its influence on timeliness. Wisner (2003) stated that the faster and more flexible logistics system are, the more successfully customer needs are fulfilled. Schramm-Klein and Morschett (2006) acknowledge this relation and show a highly significant relation between logistics performance and the strategic long-term aspects of marketing performance (e.g., customer satisfaction and loyalty). This indicates that the basis for improving the total of all logistics service quality concepts lies in the improvement of the logistics activities.

Table 2. Logistics service quality aspects and need for customer input

Aspect	Explanation	Customer input required?
Personnel contact quality	Refers to the customer orientation of the supplier's logistics contact people	Yes
Order release quantities	Related to the concept of product availability	No
Information quality	Refers to customers' perceptions of the information provided by the supplier regarding products from which customers may choose	Yes
Ordering procedures	Ordering procedures refer to the efficiency and effectiveness of the procedures followed by the supplier	Yes
Order accuracy	Order accuracy refers to how closely shipments match customers' orders upon arrival	Yes
Order condition	Refers to the lack of damage to orders	No
Order quality	Refers to how well products work	No
Order discrepancy handling	Refers to how well any discrepancies in orders is addressed after the orders arrive	Yes
Timeliness	Refers to whether orders arrive at the customer location when promised, also refers to the length of time between order placement and receipt	Yes

Source: Adapted from Mentzer et al. (2001).

4. Lean Six Sigma Implementation frameworks

Previously to introduce our structure, this section aims to create an understanding of how LSS should be implemented in an organization. For this purpose, this section discusses existing CI implementation frameworks, and the critical success factors when introducing a CI method in an organization.

4.1 LSS application frameworks for certain processes

There are various frameworks for application of LSS. However, these frameworks are often created for a manufacturing environment only, like the ones developed by Kumar et al. (2006) and by Chen and Lyu (2009). Both frameworks have been designed and tested for one production process of the case company. Production processes, however, are not expected to be part of a logistic service environment. Consequently, these frameworks are less suitable for a logistics services environment. Other articles apply LSS to processes of other services environments than logistics, such as healthcare (De Koning et al., 2006) or local government (Furterer and Elshennawy, 2005). The purpose of these articles is to show that LSS may also be used in other (i.e., services focused) environments than manufacturing. Unfortunately, the coverage of business services in these papers is not very broad. The article of Su et al. (2006) is an exception because the authors intended to create a framework to improve service quality in general, instead of developing the framework for just one process. Therefore, Su et al.'s (2006) is the only framework that could be helpful in creating a framework for logistics services environment.

Like most LSS implementation frameworks (cf. Kumar et al., 2006; and Chen and Lyu, 2009) the LSS methodology for service quality improvement proposed by Su et al. (2006) starts from the DMAIC approach (Define – Measure – Analyze – Improve – Control).

The DMAIC approach originates from Six Sigma. The model of Su et al. (2006) is the only framework found in literature which clearly combines the application guidelines of both Lean and Six Sigma. The framework's focus on services becomes clear in the 'Define' phase where the voice of the customer is categorised in the five dimensions of service quality. These five dimensions are derived from Parasumaran et al. (1988): tangibility, reliability, responsiveness, assurance, and empathy. The same dimensions also form the basis of the nine quality aspects of Mentzer et al. (2001), explained above. Because of this, the conceptual basis of the model of Su et al. (2006) is in line with the characteristics of a logistics services environment. Because of this similarity, and the creating of a framework for the service processes in total, the LSS model of Su et al. (2006) is expected to be suitable in a logistics services environment.

The LSS application in a logistics services environment can reduce seven different wastes associated to logistics service: inventory, transportation, space and facilities, time, packaging, administration and knowledge (Goldsby and Martichenko, 2005). These authors specify that LSS pursues "the elimination of wastes through disciplined efforts to understand and reduce variation, while increasing speed and flow in the supply chain" (Goldsby and Martichenko, 2005, p.25).

However, many organizations that have applied a CI-method have not been successful in achieving their goals (Anand et al., 2009; Chakravorty, 2009a). The application of a LSS framework to a process in an organization is not enough to be successful with implementation. It therefore does not make sense to create an LSS model for a logistics services environment without taking into account other critical success factors related to organizational implementation. For this reason, the next section reviews ideas related to successful organizational implementation.

4.2. LSS critical success factor and organizational implementation frameworks

There is a lack in literature related to critical success factors (CSFs) when implementing Lean Six Sigma. Recently, Psychogios and Tsironis (2012) found that there are several factors that affect LSS in the airline industry, such as leadership and strategic orientation, quality-driven organisational culture, continuous training, teamwork, customer satisfaction, and technical systems. These aspects are relevant to successful LSS implementation.

Despite this lack in literature, Naslund (2008) stated that Lean and Six Sigma both have similar and generic critical success factors. Literature shows that the area of management involvement and organizational commitment is the most important area to focus on when implementing LSS in a service environment (Antony, 2004; Brun, 2010). Table 3 gives an overview of literature review on critical success factors when implementing Six Sigma or Lean Manufacturing separately, that can be extrapolated to LSS (Naslund, 2008). We have structured the table based on the elements analyzed by Kwak and Anbari (2006).

Table 3. Critical success factors of LSS categorised

Four elements of Kwak and Anbari (2006)	Six Sigma Critical Success Factors	Lean Manufacturing Critical Success Factors
Management involvement and organizational commitment	- Linking Six Sigma to business strategy (Brun, 2010; Antony, 2004) - Customer focus/linking 6S to customer (Antony, 2004; Brun, 2010) - Management commitment (Brun, 2010; Antony, 2004) - Organizational infrastructure (Brun, 2010; Antony, 2004) - Management involvement (Brun, 2010)	- Leadership (Achanga et al., 2006; Anvari et al., 2010) - Management involvement (Achanga et al., 2006) - Organizational culture (Achanga et al., 2006; Anvari et al., 2010; Lee and Allwood, 2003)
Project selection, management, and control skills	- Project management skills (Antony, 2004)	- Project Management (Achanga et al., 2006; Anvari et al., 2010)

		- Financial capabilities (Achanga et al., 2006; Anvari et al., 2010)
Continuous education and training	- Training (Brun, 2010)	- Skills and expertise (Achanga et al., 2006; Anvari et al., 2010) - Education and plan (Anvari et al., 2010) - Learning (Lee and Allwood, 2003)

Some studies develop organizational implementation frameworks for CI. For example, Chakravorty (2009a) stated that one reason why many Six Sigma programs fail is because an implementation model on how to effectively guide the implementation of these programs is lacking and not available in literature. A more conceptual approach to the implementation of CI is the one from Anand et al. (2009). They presented a framework of infrastructure based on the idea that continuous improvement is meant to be a dynamic capability. Anand et al. (2009) stated that all the decision areas in the framework play a critical role in shaping and sustaining of any CI initiative.

Nevertheless, these organizational implementation models lack the detailed information of the models described in previous section, like the DMAIC approach or LSS tools. They only focus on the organizational aspects of implementing LSS. Therefore, these models cannot be seen as complete LSS frameworks. On the other hand, the application models of the previous section need to include organizational aspects to be successful. However, there are no articles found in literature which combines these different models. Consequently, literature has never proposed a global framework for LSS implementation.

5. A global framework for LSS implementation

The proposed framework takes as its starting point the articles of Chakravorty (2009a) and Su et al. (2006). However, our proposal seeks to overcome their limitations and we adapted the framework to logistics services. On the one hand, the framework of Chakravorty (2009a) is used for organizational implementation, since this framework is the only clearly defined organizational roadmap found in literature in this area. On the other hand, the framework developed by Su et al. (2006) is the only LSS application framework found that uses the application guidelines of both Lean and Six Sigma. This framework is designed for a non-manufacturing environment and also has a focus on improving service quality in general, which can easily be translated to the service quality of a logistics services environment. Using these contributions, we developed a global framework, explained below (see figure 1).

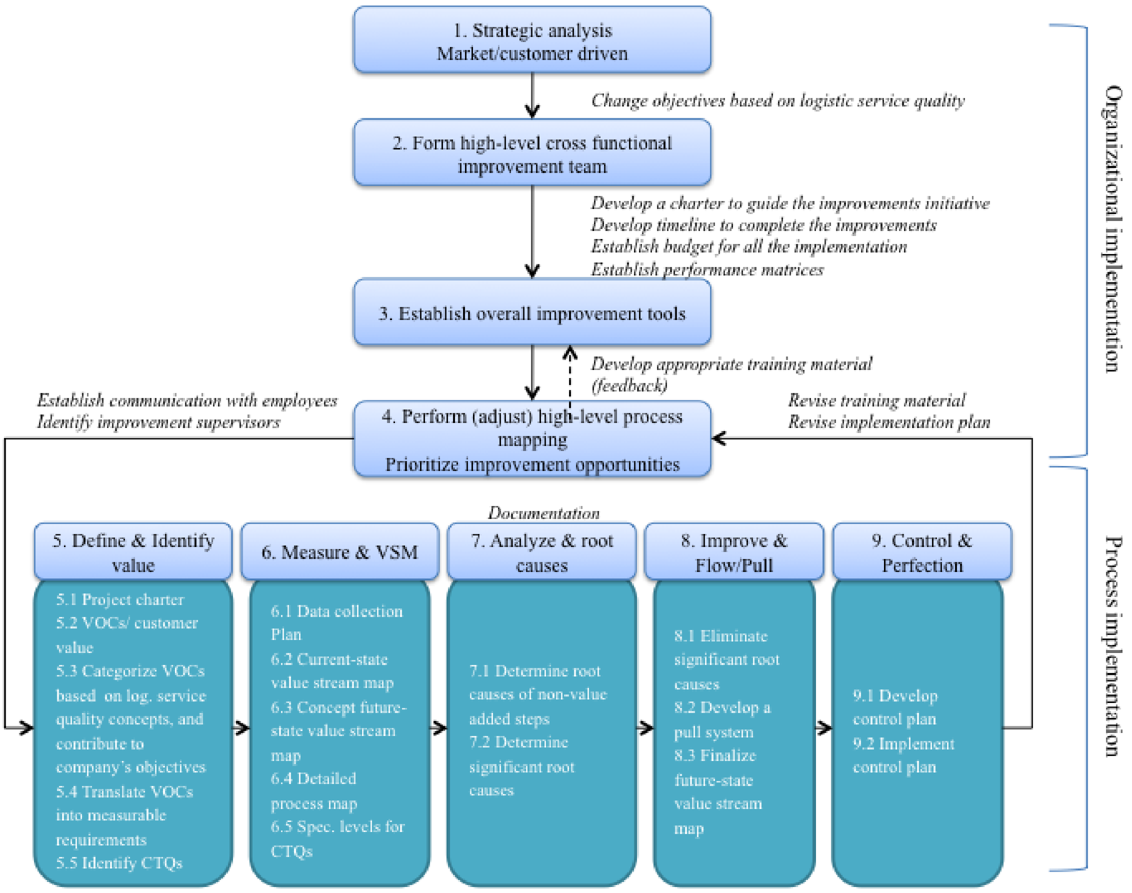

Figure 1. Proposed framework for logistics service environments

Our global proposed framework is structured as follows. The first four steps of the organizational framework of Chakravorty (2009a) are used in the proposed framework. The original last two steps are omitted, because these are absorbed by the implications of the process application framework of Su et al. (2006). To clarify, the step/deliverable 'Detailed plan and the formation of low level improvement teams' (Chakravorty, 2009a) is included in the developing of a project charter (George, 2003). Also, the step 'Implementation, documentation and revision' (Chakravorty, 2009a) is described in more detail in the proposed framework by using the implementation steps of Su et al. (2006). Moreover, some changes are made in certain steps. The changes made are based on the literature review described above. Below we will explain each step of the framework and associated propositions.

5.1. Organizational implementation and propositions

Step 1: Strategic Analysis

The first step of the framework is to perform a strategic analysis which is customer/market driven (Chakravorty, 2009a). Two critical success factors are fulfilled in this step: 'Linking LSS to business strategy' and 'Linking LSS to the customer'. The deliverable of this step is to create objectives, or to speak in terms of Anand et al (2009) create the 'purpose' of this CI implementation.The main elements in manufacturing strategy formulation and decision making are quality, delivery, flexibility and cost (Beach et al., 2000; Tamayo-Torres et al., 2014). All these objectives are closely related and some authors affirm that they can be pursued jointly (Ferdows and De Meyer, 1990; Narasimhan and Schoenherr, 2013; Takala et al., 2006). In this sense, organizations must look for a successful competitive capabilities development, where quality is the capability that supports the development of the rest of capabilities, the "foundational capability" (Ferdows and De Meyer, 1990; Narasimhan and Schoenherr, 2013; Takala et al., 2006).

Thus, organizations may emphasize different quality aspects (Heskett 1971). It is therefore important that objectives are clear, and the communication to the low level processes is in place. Furthermore, using Lean Six Sigma means that quality should be embedded in the company's functions and departments (Brun, 2010). Therefore, each process should know its contribution to the high-level process quality and relate its objectives to it. As step 5 will show, low level improvement teams have to define their objectives in terms of the nine logistics quality aspects of Mentzer et al. (2001). To make the translation from strategic objectives to low level processes easy, strategic objectives should be defined in terms of the nine logistics service quality aspects as well. In this sense, for example, Hoshin Kanri or Policy development methodology that fosters shared vision and objectives communication among all the organizational members could support this step. This study expects that, in this way, the improvements will be better linked to the business strategy, which lead to higher business performance.

Proposition 1: Strategic objectives have to be defined based on logistics service quality aspects in order to reach higher business performance.

Step 2: Form high-level cross functional improvement team

As Naslund (2008) and Brun (2010) stated, improvement initiatives do not seem to be very successful when they use a functional approach or are focused at individual departments only. Step 2 of the proposed framework overcomes this problem by creating a high level and cross functional improvement team. Following Chakravorty (2009a) step 2 is also important to effectively guide CI initiatives and keep management involvement. The deliverables of this second step include an important part of the organizational infrastructure, which is needed for successful implementation (Anand et al., 2009). Here, resources to guide (e.g. a project charter, timeline) and support (e.g. people, performance matrices) the implementation are installed. In this step one can specifically focus at critical success factors ‘organizational infrastructure’ and ‘organizational commitment’. Especially performance matrices can be really helpful, because with service processes, measurement is often an overlooked area and therefore, improvement of quality is not adequately addressed by many service-oriented businesses (Antony, 2004).

Proposition 2: Improvement initiatives are not successful if they use a functional approach or are focused at individual departments only.

Proposition 3: Creating a measurement system at organizational level is necessary for successful process implementations.

Proposition 4: In order to have successful process implementations, an organizational infrastructure should be in place before applying LSS to a process.

Step 3: Establish overall improvement tools

The objective of this step is to develop appropriate training material (Chakravorty, 2009a). However, the question remains which training material is appropriate. LSS tools are not clearly defined and their application may differ considerably. Prior to implementing LSS tools, companies must develop deep problem-solving capabilities in their employees, through the “learning by doing” process (Chakravorty, 2009b).

By continuously revising the training material and adjusting the available training material in the organization, new improvement initiatives can benefit. In the proposed framework (Figure 1) this process is added and indicated by the dotted line from step 4 to step 5. The critical success factor, described by Brun (2010), to have appropriate training material available, is in this way fulfilled.

Proposition 5: Revising training material is needed to make new CI projects more successful.

Step 4: Perform high-level process mapping / Prioritize opportunities

The fourth step is to perform high level process mapping and prioritize improvement opportunities (Chakravorty, 2009a). High level process mapping can be defined as an activity that pursues to identify improvement alternatives through the understanding of the existing flow of information of processes and its associated value creation (Chakravorty, 2009a). By continuing coming back to the fourth step, the organization guarantees management involvement. Management involvement is one of the most critical success factors. The creation of high level process mapping, prioritize initiatives, and setting goals for low level improvement projects cannot be done without management involvement. Moreover, a logistics service environment often interacts with a manufacturing supply chain. This means that those processes that belong to a logistics service environment are interrelated and all have their influence on the total supply chain. Therefore, it is important to keep coordinating these processes to create an efficient supply chain. This is also in line with the total system approach of LSS. Moreover, with a measurement system at organizational level (proposition 4) prioritization will be easier since measurements can be placed in the context of the whole supply chain. This supports proposition 4.

Proposition 6: Due to its relation with the manufacturing supply chain, a logistics service environment needs continuous revision of high-level processes.

Proposition 7: Continuous revision of high-level processes creates management involvement.

An outcome of step 4 is to establish communication about the CI implementation with the employees. The strategic objectives have to be communicated to the low level improvement teams as well. When an organization wants to use LSS successfully all employees has to recognize their quality responsibility. Chakravorty (2009a) experienced considerable difficulty in identifying and prioritizing CI projects in alignment with overall process improvement objectives. These points strengthen the need to translate the strategic objectives into the nine logistics service quality aspects (proposition 1).

Another result of step 4 is the identification of improvement supervisors. Following Chakravorty (2009a) improvement supervisors are essential to have good communication between low level improvement teams and manager. This will also have its influence on the perspective of employees on the critical success factor 'Management involvement/commitment'.

Proposition 8: Improvement supervisors are needed for successful communication and creation of management involvement.

5.2 Process implementation and propositions

The remaining steps of the proposed framework are based on the model of Su et al. (2006). Some adjustments are made on certain steps due to findings of the literature reviews and due to the integration of the model of Chakravorty (2009a).

Step 5: Define and Identify value

1. Create a project charter: The project charter should include a business case, project goals and objectives, milestones, project scope/constraints/assumptions, team

memberships, roles and responsibilities, and a preliminary project plan. The goals and objectives of the project should be in line with the strategic objectives in order to overcome the CSF of linking LSS to the business strategy. A SIPOC (supplier-input-process-output-customer) tool can be used to identify all relevant elements of the project.

2. Identify the Voice of the Customer (VOCs)/customer value: Both external and internal customers of the process are identified, and their needs are collected and analyzed (Su et al., 2006).

3. Categorize the VOC based on nine dimensions of logistics service quality. Instead of using the five service quality concepts described by Su et al. (2006), the proposed framework will use the nine logistics service quality aspects developed by Mentzer et al. (2001). If there is any VOC that falls beyond the scope of the nine dimensions, then it is set aside for managers to consider for additional action (Su et al., 2006).

4. Translate the VOC into measurable requirements: the VOC could be disorganized, non-specific or qualitative in nature, and therefore need to be translated into measurable requirements (Su et al., 2006).

5. Identify critical-to-quality characteristics (CTQs); Identify the relatively important requirements to logistics service quality based on the perspectives of customers and employees (Su et al., 2006), while contributing to the objectives coming from the strategic analysis.

Proposition 9: Definition and categorization of the VOC should be based on the nine quality aspects, and the CTQs should be aligned with the strategic objectives.

Step 6: Measure/ VSM

1. Create data collection plan: The objective is to determine issues such as sampling frequency, who will perform the measurement, the format of data-collection form and the measuring instruments (Su et al. 2006). A Gauge R&R can be used to validate the measurement system. Finally, data can be collected in order to measure the CTQs. This study expects that a measurement system at organizational level is needed to pass this phase efficiently (see proposition 5).

2. Construct current-state value stream map: A value stream map shows the work processes as they currently exist (Su et al. 2006).

3. Construct draft future-state value stream map: based on the current state a draft of the future-state value stream map can be made; doing this creates ideas for improvements (Su et al. 2006).

4. Develop detailed process map: Value stream mapping (VSM) has some limitations. For example, it will not begin with capturing all specific actions, and it will not address non-technical/human issues (Su et al. 2006). VSM is a Lean tool, while a 'process mapping' is a Six sigma tool (Chen and Luy, 2009). Process mapping identifies process outputs and ultimate output to a customer as well as process inputs and may thus provide a detailed look at a process. Therefore, to create the benefits from the integrated methods, a detailed process map should be developed next to VSM.

5. Determine specific levels of CTQs: Set goals for achieving the desired or acceptable levels of logistics service quality of both the customers and employees (Su et al. 2006). Contribute to the organizational objectives (see also proposition 9).

Proposition 10: Both VSM and process mapping are needed to come to a total overview of the process and create the benefits of the LSS method.

Step 7: Analyze/ determine root causes

1. Determine root causes of non-value added steps: Identify and validate the root causes of why the defects occur in the non-value-added steps (Su et al. 2006).

2. Determine significant root causes: Once the significant root causes are identified, they are in priority to be removed from the service processes (Su et al. 2006).

Proposition 11: Thorough data and process analysis are required for root cause identification.

Step 8: Improve/ Flow & Pull

1. Eliminate significant root causes: Select a solution to exterminate the significant root causes that have the most impact on the CTQs (Su et al. 2006).

2. Develop a pull system: Make the value-creating steps occur in tight sequence and eliminate the non-value-added steps so as to dramatically reduce the flow time[2] through the processes and pull customers' demand for services (Su et al. 2006).

3. Finalization of future-state value stream map: once improvements have been defined and detailed and the pull system developed a finalized future-state value stream map can be made.

Proposition 12: Improvements are only successful if companies focus on both eliminating root causes and on decreasing flow time

Step 9: Control / Perfection

[2] The flow time of a process can be defined as the length of the time interval that starts at the moment that it is decided to start the process until the moment that the process has ended (Adapted from Teunter and Flapper, 2006).

1. Develop control plan: make sure that the solutions are sustainable. The control of the logistics service process must occur at both the strategic and tactical levels (Su et al. 2006).

2. Implement control plan; It is needed to keep track of the process performance after improvement, also to control the critical variables relating to performance (Su et al. 2006). A measurement system on organizational level (propositions 5) can be helpful in controlling the performance.

Proposition 13: A control plan should be sustainable and implemented at operational as well as organizational level.

Following Kumar et al. (2006), valuable lessons should be learned from previous projects and should be taken care of while starting a new project. To create continuous improvement the implementation plan should be revised after a process implementation and documentation should be in place during the process implementation (Chakravorty, 2009a).

Proposition 14: Documentation and revising are important to reach continuous improvement.

6. Conclusion and further research

Lean Six Sigma is a continuous improvement initiative with a long-term strategic decision-making orientation which maximizes value added content and minimizes variation of quality and process characteristics, thereby improving customer satisfaction. It constitutes an integration of the methods Lean and Six Sigma, where the strengths of one method rebut the weaknesses of the other method.

This paper provides an implementation framework for LSS implementation. The proposed framework incorporates a global implementation perspective on the one hand, and is, on the other hand, adapted to logistics services environments. The paper also includes a list of propositions to explain the functioning of the framework. The proposed framework and its propositions constitute a relevant contribution to LSS literature and, generally, to CI literature.

Regarding managerial implications, the present paper offers three main contributions. Firstly, this paper offers argumentation about the adequacy of LSS implementation over other alternatives. Secondly, the proposed framework constitutes an illustrative guide that can be followed by practitioners who decide on LSS implementation. Finally, managers operating in the Supply Chain area, and specifically logistics, can find relevant information about specific LSS features and success factors.

However, this research also has some limitations. We found that there is little literature on how to apply Lean Six Sigma. By combining literature on Lean and Six Sigma this study tried to overcome this problem. Furthermore, as a theoretical contribution, the absence of empirical support of our framework and propositions limits its interpretation. Future research should therefore be focused on empirically analysing the practical issues of this model. A case study could constitute a good opportunity to perform this analysis. Finally, this study mentioned the interdependence of logistics activities and the increasing attention on Supply Chain Management in literature (Rahman, 2006). This study has focused mainly on internal processes in relation to Lean Six Sigma. Further research on Lean Six Sigma in this area should have a focus on the total supply chain.

References

Achanga, P., Shehab, E., Rajkumar, R. & Nelder, G. (2006). Critical success factors for lean implementation within SMEs. *Journal of Manufacturing Technology Management*, 17 (4), 460-471.

Anand, G., Ward, P.T., Tatikonda, M.V. & Schilling, D.A. (2009). Dynamic capabilities through continuous improvement infrastructure. *Journal of Operations Management*, 27, 444-461.

Antony, J. (2004). Six Sigma in the UK Service organisations: results from a pilot survey. *Managerial Auditing Journal*, 19 (8), 1006-1013.

Anvari, A.R., Norzima, Z., Rosnay, M.Y., Hojjati, M.S.H. & Ismail, Y. (2010). A comparative study on journey of lean manufacturing implementation. *AIJSTPME*, 3 (2), 77-85.

Arnheiter, E.D. & Maleyeff, J. (2005). The integration of Lean management and Six Sigma. *The TQM Magazine*, 17(1), 5-18.

Beach, R., Muhlemann, A.P., Price, D.H.R., Paterson, A. & Sharp, J.A. (2000). A review of manufacturing flexibility. *European Journal of Operational Research*, 122 (1), 41–57.

Bhuiyan, N. & Baghel, A. (2005). An overview of continuous improvement: from the past to the present. *Management Decision*, 43 (5), 761-771.

Brun, A. (2010). Critical success factors of Six Sigma implementations in Italian companies. *International Journal of Production Economics*, 131, 158-164.

Chakravorty, S.S. (2009a). Six Sigma programs: An implementation model. *International Journal of Production Economics*, 119, 1-16.

Chakravorty, S.S. (2009b). Process Improvement: Using Toyota's A3 Reports. *The Quality Management Journal*, 16 (4), 7-26.

Chapman, R.L., Soosay, C. & Kandampully, J. (2003). Innovation in logistics services and the new business model. *International Journal of Physical Distribution & Logistics Management*, 33 (7), 630-650.

Chen, M. & Lyu J. (2009). A Lean Six Sigma approach to touch panel quality improvement. *Production planning & control*, 20 (5), 445-454.

CSCMP, (2011). CSCMP Supply Chain Management Definitions. [online] Available at: <http://cscmp.org/aboutcscmp/definitions.asp> [Accessed 20 April 2011].

De Koning, H., Verver, J.P.S., Van den Heuvel, J., Bisgaard, S. & Does, R.J.M.M. (2006). Lean Six Sigma in Healthcare. *Journal for Healthcare Quality*, 28(2), 4-11.

Devane, T. (2004). Integrating Lean Six Sigma and High-Performance Organizations. *John Wiley & Sons, Inc., New York.*

Ellram, L.M., Tate, W.L. & Billington, C. (2004). Understanding and managing the services supply chain. *Journal of Supply Chain Management*, 40 (4), 17-32.Ferdows, K. & A. De Meyer. (1990). Lasting Improvements in Manufacturing Performance: In Search of New Theory. *Journal of Operations Management* 9 (2), 168–184.

Fung, P. & Wong, A. (1998). Case study: managing for total quality of logistics services in the supply chain, *Logistics Information Management*, 11(5), 324-329.

Furterer, S., & Elshennawy, A.K. (2005). Implementation of TQM and Lean Six Sigma tools in local government: A framework and a case study. *Total Quality Management and Business Excellence*, 16 (10), 1179–1191.

George, M.L. (2003). Lean Six Sigma for service: how to use Lean speed and Six Sigma quality to improve services and transactions. *McGraw-Hill, New York, USA*.

Gnanaraj, SM, SR Devadasan, R Murugesh, & CG Sreenivasa (2012). Sensitisation of SMEs Towards the Implementation of Lean Six Sigma–an Initialisation in a Cylinder Frames Manufacturing Indian SME. *Production Planning & Control*, June, 37–41.

Goldsby, T. J. & Martichenko, R. (2005). Lean Six Sigma Logistics. Boca Raton, FL, USA: *J. Ross Publishing*.

Heskett, J.L. (1971). Controlling customer logistics service. *International Journal of Physical Distribution & Logistics Management*, 1(3), 141–145.

Kumar, M., Antony, J., Singh, R.K., Tiwari, M.K. & Perry, D. (2006). Implementing the Lean Six Sigma framework in an Indian SME: a case study. *Production planning & control*, 17(4), 407-423.

Kwak, Y.H. & Anbari, F.T. (2006). Benefits, obstacles, and future of Six Sigma approach. *Technovation*, 26, 708-715.Lee, W.L. & Allwood, J.M. (2003). Lean manufacturing in temperature dependent processes with interruptions. *International Journal of Operations & Production Management,* 23 (11/12), 1377-1400.

Mentzer, J.T., Flint, D.J. & Hult, T.M. (2001). Logistics Service quality as a Segment-Customized Process. *Journal of Marketing*, 65, 82-104.

Narasimhan, R., & Schoenherr, T. (2014). Revisiting the progression of competitive capabilities: results from a repeated cross-sectional investigation. *International Journal of Production Research*, 51 (22), 6631–6650.

Naslund, D. (2008). Lean, six sigma and lean sigma: fads or real process improvement methods? *Business Process Management Journal*, 14(3), 269 -287

Parasuraman, A., Zeithaml, V.A. and Berry, L.L. (1988). SERVQAUL: a multiple-item scale for measuring customer perceptions of service quality. *Journal of Retailing*, 64(1), 12-40.

Pickrell, G., Lyons, H.J., & Shaver, J. (2005). Lean Six Sigma implementation case studies. *International Journal of Six Sigma and Competitive Advantage*, 1(4), 369–379.

Psychogios, A.G., & Tsironis, L.K. (2012). Towards an integrated framework for Lean Six Sigma application: Lessons from the airline industry. *Total Quality Management and Business Excellence*, 23 (4), 397–415.

Rahman, S. (2006). Quality management in Logistics: an examination of industry practices. *Supply chain Management: An International Journal*, 11 (3), 233-240.

Sampson, S. E., Froehle, C.M. (2006). Foundations and implications of a proposed unified services theory, *Production and Operations Management*, 15 (2), 329-343.

Schramm-Klein, S. & Morschett, D. (2006). The Relationship between Marketing Performance, Logistics Performance and Company Performance for Retail Companies. *International Review of Retail, Distribution and Consumer Research*, 16(2), 277-296.

Sohal, A. S. & Egglestone, A. (1994). Lean production: Experience among Australian organizations. *International Journal of Operations & Production Management*, 14 (11), 35.

Sousa, R. & Voss, C.A. (2002). Quality management re-visited: a reflective review and agenda for future research. *Journal of Operations Management*, 20, 91–109.

Swink, M. & Nair, A. (2007). Capturing the competitive advantages of AMT: Design–manufacturing integration as a complementary asset. *Journal of Operations Management*, 25(3), 736-754.

Su, C-T., Chiang, T-L. & Chang, C-M. (2006). Improving service quality by capitalising on an integrated Lean Six Sigma methodology. *International Journal of Six Sigma and Competitive Advantage*, 2(1), 1–22.

Takala, J., Leskinen, J., Sivusuo, H., Hirvelä, J. & Kekäle, T. (2006). The sand cone model: illustrating multi-focused strategies. *Management Decision*, 44 (3), 335-345.

Taghizadegan, S. (2006). Essentials of lean six sigma. Amsterdam. Boston, Mass. *Elsevier*.

Tamayo-Torres, J., Gutierrez-Gutierrez, L. & Ruiz-Moreno, A. (2014). The relationship between exploration and exploitation strategies, manufacturing flexibility and organizational learning: An empirical comparison between Non-ISO and ISO certified firms. *European Journal of Operational Research*, 232 (1), 72–86.

Tathem, M. & Mackertich, N. (2003). Is Six Sigma falling short of expectations? *Optimize*, 19-21.

Teunter, R. & Flapper, S. (2006). A comparison of bottling alternatives in the pharmaceutical industry. *Journal of Operations Management*, 24 (3), 215-234.

Wang, F.K. & Chen, K.S. (2010). Applying Lean Six Sigma and TRIZ methodology in banking services. *Total Quality Management & Business Excellence*, 21 (3), 301-315.

Wang, F.K. & Chen, K.S. (2012). Application of Lean Six Sigma to a panel equipment manufacturer. *Total Quality Management & Business Excellence*, 23 (3-4), 417-429.

Wisner, J. D. (2003). A structural equation model of supply chain management and firm performance. *Journal of Business Logistics*, 24 (1), 1–26.

Worley, J. M. & Doolen, T.L. (2006). The role of communication and management support in a lean manufacturing implementation. *Management Decision*, 44 (2), 228-245.