Applications of Lean Six Sigma (LSS) in Production Systems

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Abstract

This research paper presented the applications of Lean Six Sigma (LSS) in production systems. This narrative research is based on the review of previous studies. Literature review is summarized, discussed and presented in tables. Since, the quality improvement & defects reduction have been the severe problem in industries due to its association with cost; thus it has been the focus of academicians and practitioners to study and implement such quality improvement & defects reduction philosophy. Since, lean manufacturing is an effective waste elimination technique and its tools have captured the immense attention of academicians and practitioners for quality improvement & defects reduction. Therefore, there is an extreme need to conduct such studies about the usefulness and drawbacks of the implementation of lean tools. In future, other lean tools can be discussed in depth to put clearer and broader picture and to draw more comprehensive conclusion. Moreover, existing studies lack to investigate the implementation in various sectors. Studies related to LSS are significantly important in development of lean knowledge due to individual sectors have major differences in their processes. In this regard, present review is conducted so as to put the open and broader picture of Lean Six Sigma (LSS) comprehensively.

Keywords:

lean manufacturing; lean six sigma (LSS); defects; six sigma; quality.

1. Introduction

Currently around the globe, companies based on manufacturing require to keep their production level sustainable as per customer demand. When they appears any capacity related problem, instantly they look ahead to increment in number of shifts, increases overtimes and purchase new equipment or machines(NALLUSAMY et al., 2018). During manufacturing process, the machines plays a pivotal role to keep the production smooth in other case production can confront several inhibits(Nurprihatin et al., 2019). On the other hand, the focus should remain on harnessing better resources and surging in performance of the machines that already exists which could pursue in reducing bottlenecks, improvising performance of equipment, curb overall downtime, turn operator performance efficient and reduce setup time and other loses, hence enabling in any decision on the investment of purchase of new machines (NALLUSAMY et al., 2018). In order to stay competitive and confront market pressures, companies requires to bring efficiency and productivity. Since very long, several companies are utilizing lean manufacturing systems pursuing Toyota model to curb wastage in-process and expand their added value(Lugert et al., 2018). Lean manufacturing has resulted in recent time as a resilient substitute that, if adopted at balance level by various actor through supply chain, deduce satisfactory results in making significant profits (Romero & Arce, 2017). Toyota in the 1940-50s developed it, since then, lean has proven to be one of the significant managerial paradigms in business environments as empirical and theoretical evidence has highlighted its efficiency to expand the organizations'

competitiveness(Garza-Reyes et al., 2018). The commencement of lean manufacturing was developed to reduce down waste in the automobile sector, (De Steur et al., 2016) defined at as "a system that utilizes fewer inputs and creates the same out- puts while contributing more value to customers".

Rajput et. al. (2020) conducted the case study at the automobile assembling plant to improve the productivity. The authors applied the lean tools and techniques to identify the causes of low productivity and proposed the lean manufacturing practices for the expected productivity improvement at the automobile assembling plant. The authors have also compared the the pre and post productivity measures. Khan et. al. (2020) conducted the comprehensive review of lean manufacturing in Pakistan. The authors have identified the potential, benefits and applications of lean manufacturing in the various manufacturing sectors of Pakistan. The authors have mentioned the case studies to support the growing awareness and increasing scope of lean manufacturing in the major industrial sectors of Pakistan. Sahito et. al. (2020) conducted the case study at the pharmaceutical plant to Identify, analyses and elimination the Lean Manufacturing Wastes through Lean Manufacturing Practices. The authors have identified the lean manufacturing wastes in pharmaceutical plant by lean standards and then analysis is performed by using the statistical tools and techniques. The authors, then suggested the most suitable lean practices for eliminating/reducing the most significant wastes at the pharmaceutical plant and compared the pre and post scenario.

The day to day practice to quality has stressed upon on either reducing variation or increasing variation within the process. On the contrary, the consumption of time is in reducing variation as it is requisite for careful identification of the prior selective factors to deduce a proficient solution for improvising wherein the point of quality is not debatable even then time factor is conceded(Muraliraj et al., 2018). In the past decade, the slowdown of economics has pushed to critical sense of surge in organization to increment productivity and reduce costs, without harming existing quality of output(Sreedharan V et al., 2019). As far as quality is concerned, lean Six Sigma (LSS) is a comprehensive system for securing and keeping business success sustainable through comprehending data discipline, customer need; to add value by minimizing waste; and intelligent attention to managing, organizing and improvement in process(Knapp, 2015). In the present research paper, literature review of above one of the major lean tool i.e. Lean Six Sigma (LSS) has been conducted in the context of different industries.

2. Research gap

Since, lean is waste elimination technique and its tools have captured the immense attention of businessmen and the academicians. It has been reported that studies lack which examine the lean six sigma implementation in various sectors. Such studies are significant and need of the hour for the development of lean knowledge because individual sectors have fundamental variance in their construction, production or service processes (Shou et al., 2017). In this regard, present review was conducted so as to put the open and broader picture of one of the major lean tool i.e. Lean Six Sigma (LSS) comprehensively.

3. Aim and objectives

This research aimed to present the applications of one of the major lean tool i.e. Lean Six Sigma (LSS) in the various industrial sectors along with their effectiveness, impacts and their useful outcomes after implementation.

- To discuss the applications of Lean Six Sigma (LSS) in various types of industries in detail
- To highlight the effectiveness of mentioned tools in industrial productivity

4. Research methodology

A narrative literature review was conducted to put the detailed and broader picture of one of the major lean tool i.e. Lean Six Sigma (LSS) in terms of its implementation in industrial world.For the analysis of literature, narrative review is used and it enables anextensive understanding of problems and controversies associated with the use of technology and at the same time, it helps to take out the key success factors of adopting and using technologies (Frennert & Östlund, 2018) . By this method, researchers conduct analysisof debates and outcomes of already conducted research; moreover, it helps in figuring out the research gap and future implications (Ferrari, 2015). Present research paper, summarizes the data and evidences as collected from the previously conducted research on the implementation of one of the major lean tool i.e. Lean Six Sigma (LSS).

4.1 Data Collection

This narrative research was based on the secondary data which was collected from the previously conducted empirical studies, case studies and literature reviews. Research papers on the implementation of mentioned lean

tools were downloaded and most suitable research papers on the Lean Six Sigma (LSS) are mentioned and were considered for the literature review. The data was extracted from those papers and was organized into the tables.

4.2 Data Analysis

Literature review was presented and summarized in the form of tables and graphs. For the data analysis of the collected data, MS excel was used for data organization in tables and plotting graphs.

5. Literature review

Literature review has been carried out on one of the major lean tool i.e. Lean Six Sigma (LSS). The literature review is produced under multiple headings and summary.

5.1 Lean Six Sigma

Competitive globalized business environment, production cost cutting is a primary issue before operation managers. As a research area, green lean six sigma (GLS) is proposed to have strategic importance in product development towards cutting costs, contributing to optimization, and achieving sustainability(Kumar et al., 2016). The success of LSS depends largely on the organizational culture and work practices (Raja Sreedharan & Raju, 2016). Lean Six Sigma has broad applicability including not only manufacturing but also service, healthcare, government, non-profits and education. It is useful in small and medium size organizations as well as large organizations (Anotony et al., 1987). Lean manufacturing has been acknowledged as a methodology to eliminate waste, while Six Sigma has been regarded as a diagnostic tool to improve processes by eliminating variation(Dora & Gellynck, 2015).It has been shown that within SMEs the main motivational factors are predominantly operational with the aim to increase quality, reduce costs and increase profits(Alexander et al., 2019).The important objective of both of the methodologies is to identify the most critical processes to generate savings for an organization. Lean Six Sigma integrates these two approaches into an effective hybrid method, which combines the variability elimination tools from Six Sigma with the waste elimination practices from lean manufacturing (Dora & Gellynck, 2015). Although the popularity of the Lean Six Sigma methodology has illustrated many benefits over the years for those organizations who have implemented it, this strategy has received less attention in developing countries(Albliwi et al., 2012).

Khan, Memon & Soomro (2020)explored major lean manufacturing practices in the automobile industry and highlighted the applications of popular lean practices including the Lean Six Sigma (LSS) for the auto industry. The authors mentioned the substantial benefits of the applications of highlighted lean practices in the specific segments of the automobile industry.

Raja and Raju, 2016 conducted a review on lean six sigma (LSS) reflecting the spread principles, and scope of LSS. It was indicated by the review that LSS research is mainly focused on manufacturing sector, but LSS has spread to other type of industries also. However, the adoption of LSS in SMEs is not widespread. Because of the implementation cost and uncertainty and lack of clear roadmap for deployment.Most of the LSS articles were focused on the Empirical type of research which shows that LSS can solve complex problems because of its data driven approach.The success of LSS depends largely on the organizational culture and work practices. Most of the industries LSS yet to be adopted as part of their organization's culture.LSS Spread has found applications from manufacturing to service sector; labor-intensive industries to technology intensive industries; mass production to high variety and small volume production; medical health care to communication industry; construction industry to assembly industry; Logistics industry to defense. This show the spread of LSS in Various organizations and justify the fact that LSS is one of the best strategy for organizational excellence (Raja Sreedharan & Raju, 2016).

Swarnakar and Vinod, 2016 aimed to deploy LSS framework to facilitate defect reduction and enhance bottom line results of an automotive component manufacturing organization. The finding of this study is that the LSS framework has been successfully implemented in automotive component manufacturing organization, and non-value-adding activities and defects from assembly line have been reduced. The proposed LSS framework applies lean tools within Six Sigma DMAIC approach to facilitate waste elimination and defect reduction. The developed framework with linkage of DMAIC tools and techniques reduces defects and non-value-adding activities with enhanced bottom line results. The implementation of proposed LSS framework shows effective improvement in key metrics. The successful implementation of the LSS framework brings a cultural change in the automotive component manufacturing organization. There has been 50 per cent reduction in DPU, 42.18 per cent increase in OEE, 14.9 per cent reduction in changeover time, 0.1 per cent improvement in FTY, 40.35 per cent reduction in manufacturing lead

time, 7.10 per cent decrease in cycle time, 9.52 per cent decrease in manpower and 50 per cent increase in production per day for automotive component (Swarnakar & Vinodh, 2016).

Khan (2018) conducted the preliminary study on lean manufacturing practices about textile manufacturing industry. The author mentioned that he used the Gemba, Waste Relations Matrix, Cause & effect analysis, ranking and statistical techniques to identify and analyse the wastes of lean manufacturing. The seven deadly wastes of lean manufacturing are investigated and defect is identified as the most significant waste in the textile manufacturing industry. The author suggested most relevant lean practices to eliminate /reduce the most significant defect waste of lean manufacturing which include Lean Six Sigma (LSS) as well.

Kumar et al., 2016 made an attempt to address barriers in GLS product development (GLSPD) from an extensive literature review and from experts' opinions towards developing a hierarchical model structuring these barriers. Twenty-one barriers have been identified and sorted from the review of literature and were then validated through discussions with experts. Relationships (contextual in nature) among these barriers have been realized during a brainstorming session. An interpretive structural modelling (ISM) technique has been utilized for developing a hierarchical model of barriers in implementing the GLSPD process in the automobile sector of India. A nine-level structural model has been deduced after application of the ISM technique, which shows 'Competition and Uncertainty' as the topmost output of the model and 'Lack of Total Top Management Commitment' as the bottom-level input to other barriers of the model. Further, MICMAC analysis has been also done to classify these barriers for better understanding; seven barriers are identified as driver barriers, nine as dependent, five barriers as linkage and no barrier as autonomous. An analysis of interdependence and interactions among these barriers may help supply chain managers reach a better understanding of barriers. Thus, managers may be helped in prioritizing and managing barriers in order to gain a competitive advantage from GLS concept implementation in product development. GLSPD processes have been identified and proposed as an important merger of three different approaches for improving processes and products performances' parameters: environ- mental, cycle-time, speed, quality, consistency and economic. The idea behind promoting GLSPD is to incorporate various benefits of green, lean and six sigma concepts that are commonly cited by researchers and managers. Twenty one barriers to GLSPD process application in the automobile sector of India have been found appropriate to be analyzed. The ISM technique serves as an appropriate approach for identifying relationships among the barriers to implement GLSPD processes in the auto- mobile sector of India. 'Competition and Uncertainty' forms the topmost level of the model, and 'Lack of Total Top Management Commitment' completes the bottom of the model. MICMAC analysis has helped us to group these barriers into driving, linkage and dependent barriers that will further help managers and practitioners to deal with them towards their goals of attaining sustainable business proficiency. Seven barriers are found as driver barriers, whereas nine are identified as dependent. Five barriers are found as linkage and no barrier is classified as autonomous (Kumar et al., 2016).

Khan, Marri & Khatri (2020) conducted the Preliminary Study on the Identification, Analysis and Elimination of Lean Manufacturing Wastes through Lean Manufacturing Practices at Yarn Manufacturing Industry. The authors have identified the lean manufacturing wastes in yarn manufacturing industry by lean standards and then analysis is performed by using the statitical tools and techniques. The authors, then suggested the most suitable lean practices including Lean Six Sigma (LSS) for eliminating/reducing the most significant wastes in the yarn manufacturing industry.

Hussain et al., 2020 analyzed barriers to the GLS construction process (GLSCP) through a literature review and expert opinion. During brainstorming sessions, a group of experts validated the barriers and developed contextual relationships among them using a questionnaire. An 11-level hierarchal model was developed by implementing interpretive structural modelling (ISM) methodology. The Matriced Impacts Croise's Multiplication Appliqée a UN Classement (MICMAC) technique was applied to delineate these barriers into the categories of 'driving', 'linkage', and 'dependent'. While the findings indicate that all barriers are critical and play a role in hindering the application of GLS in the construction process, the top five critical barriers to GLS are an unstable political environment, lack of government policy, lack of customer involvement and awareness of GLS, lack of funds, and lack of top leadership support for GLS adoption. Usually, practitioners pay attention to one or more barriers considered important in the application of GLS. However, the existence of driving and dependence power and interactive relationships means that one barrier may influence others when implementing GLSCP. To address this issue, the ISM and MICMAC techniques were employed in this study. On the basis of a literature review and experts' opinion, 24 barriers to the implementation of GLSCP in Pakistan's construction sector were considered. The 'inefficient and traditional management of material and logistics (B6)';an 'inadequate mechanism to identify activities in the construction process to implement GLS (B14)'; and 'lack of a mechanism to assess environmental impacts (B18)' are the least

important barriers in the ISM model, while an 'unstable political environment (B20)' was confirmed as the base of the ISM model in the application of GLSCP in Pakistan. This study identified 24 barriers in the application of GLSCP in Pakistan's construction sector; however, there is room for further exploration of these barriers. The implications of this work may not be suitable for other industries that may have other valid issues. The integration of the ISM model and MICMAC technique does not interpretively explain why one barrier influences or is influenced by other barriers. Thus, to illustrate the interpretive logic for interactions among barriers, total interpretive structural modelling (TISM) could be employed in further research (Hussain et al., 2019).

Albliwi et al., 2017 aimed to asses critically the current status of Lean Six Sigma implementation in Saudi Arabian organizations. The survey was distributed to 400 organizations in Saudi Arabia using Qualtrics online software. 146 responses were received where 102 responses were completed and analyzed. The findings of the survey highlighted that the implementation of LSS is still in the early stages in organizations within Saudi Arabia. This was clearly shown by many factors such as years of deploying LSS, LSS infrastructure, level of awareness of LSS, impact of LSS on business functions and so on. The results show that there are still diverse of areas of improvement to be addressed before Saudi organizations can yield the all the expected benefits from LSS implementation. As a starting point, more focus is needed in resolving the issues on training, customers' needs, project selection and execution, investment, calculating the financial benefits, cultural changes, and effective leadership. Furthermore, improved communication between business units, employees and management, as well as the integration the Six Sigma team to all departments, would aid the understanding and implementation of LSS initiatives (Albliwi et al., 2012).

Sreedharan V et al., 2019 addressed that embracing LSS requires asking some important questions: How Lean Six Sigma Readiness (LESIRE) can be measured? How can an organization identify the barriers for LESIRE? Answers to these questions are critical to both academicians and practitioners. Authors aimed to discuss this issue. This study illustrates the development process of a Lean Six Sigma Readiness (LESIRE) evaluation model to assess an organization's readiness for LSS deployment using the fuzzy approach. Conventional models were found to be ineffective due to complexity and uncertainity. To overcome the limitations of conventional approaches, a LESIRE evaluation model was developed to determine an organization's LESIRE. The model was developed from 4 enablers, 16 criteria and 46 attributes of LSS, identified through a literature review. To demonstrate the efficiency of the model, this study testing the LESIRE evaluation model in three Indian SMEs. Using experts' ratings and weight, the researchers calculated the Fuzzy Lean Six Sigma index (FLSS) which indicates the LESIRE level of an organization and the Fuzzy Performance Importance Index (FPII) that helps to identify the barriers for LESIRE. The study centers on addressing the question of how to measure LESIRE in SMEs (Sreedharan V et al., 2019).

Knapp, S., 2015 examined the relationship between four organizational cultural types defined by the Competing Values Framework and three Lean Six Sigma implementation components management involvement, use of Lean Six Sigma methods and Lean Six Sigma infrastructure. The study involved surveying 446 human resource and quality managers from 223 hospitals located in Maine, New Hampshire, Vermont, Massachusetts and Rhode Island using the Organizational Culture Assessment Instrument. In total, 104 completed responses were received and analyzed using multivariate analysis of variance. Follow-up analysis of variances showed management support was significant, F(3, 100)¼4.89, po0.01, η2 ¼1.28; infrastructure was not significant, F(3, 100)¼1.55, p¼0.21, η2¼0.05; and using Lean Six Sigma methods was also not significant, F(3, 100)¼1.34, p¼0.26, η2¼0.04. Post hoc analysis identified group and development cultures having significant interactions with management support (Knapp, 2015).

Gutierrez-Gutierrez et al., 2016 aimed to analyze the application of Lean Six Sigma (LSS) framework for supporting continuous improvement (CI) in logistics services. Both the lean philosophy and the Six Sigma methodology have become two of the most important initiatives for CI in organizations. The combination of both alternatives – LSS – brings significant benefits for companies applying this method, and its influence in logistics services can be relevant. A case study on the logistics services of a large consumer electronics company is performed. In this sector, high quality in logistics services is crucial. Using within-case and cross-case analyses, the paper discusses the implementation of LSS in two internal logistics processes. The paper identifies important implementation aspects when applying LSS to logistics services, such as CI structure, strategic analysis, cross-functional teams and process management. Furthermore, the paper discusses the potential in logistics services of the DMAIC (define, measure, analyze, improve and control) approach and tools such as value stream mapping, SIPOC (supplier, input, process, output, and customer) and process mapping (Gutierrez-Gutierrez et al., 2016).

Dora M. and Gellynck, X., 2015 aimed to study the application of LSS in a medium-sized confectionary. The successful implementation of a LSS framework provided stimulus for establishing best practice within the whole process. The methodological implementation accomplished the reduction in overfill and defects. The improvement

led to an increase in cycle time and a reduction of machine breakdown. Overfill was one of the prime reasons of machine downtimes because wrong package sizes or out of size specifications often causing hindrances to the machine operations. A significant improvement was observed in the key performance metrics after the implementation of the LSM strategy. The study further helped with increasing the employees' morale and team feeling. Further, the managerial implication of this study is significant in the food processing industry compared with typical production, where the application of LSS methods is standard, like automotive industry. The core challenge for the food industry are the perishability of the product and the role of the climatic condition, which are often difficult to control. In most cases, food processing SMEs lack control over such critical processes (Dora & Gellynck, 2015).

Timans, W. et al., 2016 strengthen the foundations of the existing framework by uncovering evidence for some of its elements and, secondly, to identify the proposed revisions to the framework, especially focussed on its application in manufacturing SMEs. The results of our study are a collection of confirmations and revision proposals for the framework, leading to a revised conceptual framework (Timans et al., 2016). Summary of the literature review regarding LSS is presented in the table 1 given below.

Table 1. Summary of the papers from lean six sigma

Author	Industry	Findings/Outcome	Limitations / Implications
Swarnakar and Vinod, 2016	Automotive industry	The finding of this study is that the LSS framework has been successfully implemented in automotive component manufacturing organization, and non-value-adding activities and defects from assembly line have been reduced. The proposed LSS framework applies lean tools within Six Sigma DMAIC approach to facilitate waste elimination and defect reduction. The developed framework with linkage of DMAIC tools and techniques reduces defects and non-value-adding activities with enhanced bottom line results. The implementation of proposed LSS framework shows effective improvement in key metrics.	The developed framework has been test implemented in an automotive component manufacturing organization. In future, more number of studies could be conducted. Further, advanced lean tools and techniques could be included in the framework for increasing the effectiveness of production line. The proposed LSS framework with linkage ofDMAIC tools and techniques has been successfully implemented in an assembly line of automotive component manufacturing organization. This method is presently applied for an automotive component manufacturing organization; in future, the approach could be applied in different industrial sectors with addition of new tools and techniques for improving its effectiveness.
Kumar et al., 2016	Automobile Industry	Twenty one barriers to GLSPD process application in the automobile sector of India have been found appropriate to be analyzed. The ISM technique serves as an appropriate approach for identifying relationships among the barriers to implement GLSPD processes in the auto- mobile sector of India. 'Competition and Uncertainty' forms the topmost level of the model, and 'Lack of Total Top Management Commitment' completes the bottom of the model.	The model developed in this study has been based upon experts' opinions. Thus, implications of the findings may differ in different cases that may be further validated in actual problems from industry. In our study, we have analyzed 21 barriers to GLSPD in the automobile sector of India. But a similarly structured model could easily be carried out with other allied industries. Lean manufacturing was first conceived and applied in the automotive sector, but many researchers have noted its applicability to various other sectors. For those industries, appropriate barriers may be deleted or/and added as needed. To validate the existing model, structural equation modelling may be further applied. For quantification of barriers, graph theory may be applied in the future research. By dealing with the barriers researched in the present study and by tracking the successful implementation of GLS concepts in product development, the automobile industry will be better equipped to deal with uncertainty and to beat the competition, thus increasing its positioning to become globally successful.
Hussain et al., 2020	Construction industry	findings indicate that all barriers are critical and play a role in hindering the application of GLS in the construction process, the top five critical barriers to GLS are an unstable political environment, lack of government policy, lack of customer involvement and awareness of GLS, lack of funds, and lack of top leadership support for GLS adoption.	Practical analysis and verification of the findings of this work, structural equation modelling (SEM) could also be applied in the future. The results of this study can be further investigated using methodologies such as DEMATEL, AHP, ANP, and the fuzzy approach.
Albliwi et al., 2017	Saudi Arabian organizations	The findings of the survey highlighted that the implementation of LSS is still in the early stages in organizations within Saudi Arabia. This was clearly shown by many factors such as years of deploying LSS, LSS infrastructure, level of awareness of LSS, impact of LSS on	The primary limitation of this study is that data has been collected from an online survey and therefore no deeper insights could have been captured from the survey. Executing semi-structured interviews in selective organizations within Saudi Arabia were suggested in future work

		business functions and so on.	
Sreedharan V et al., 2019	Model Development	The model was developed from 4 enablers, 16 criteria and 46 attributes of LSS, identified through a literature review. To demonstrate the efficiency of the model, this study testing the LESIRE evaluation model in three Indian SMEs. Using experts' ratings and weight, the researchers calculated the Fuzzy Lean Six Sigma index (FLSS) which indicates the LESIRE level of an organization and the Fuzzy Performance Importance Index (FPII) that helps to identify the barriers for LESIRE. The study centers on addressing the question of how to measure LESIRE in SMEs	The main limitations of this study are that it did not consider the failure factors of LSS for model development and the LESIRE was only tested in manufacturing industries. Future researchers could focus on developing a model with failure factors. In future, several case studies should be carried out in different sectors like HEI, Health Care, Banking and ITES to make the model simpler for LESIRE evaluation.
Knapp, S., 2015	Healthcare	In total, 104 completed responses were received and analyzed using multivariate analysis of variance. Follow-up analysis of variances showed management support was significant, F(3, 100)¼4.89, po0.01, η2 ¼1.28; infrastructure was not significant, F(3, 100)¼1.55, p¼0.21, η2¼0.05; and using Lean Six Sigma methods was also not significant, F(3, 100)¼1.34, p¼0.26, η2¼0.04. Post hoc analysis identified group and development cultures having significant interactions with management support	Our study has several limitations. One involved measuring organizational culture. Schein (2010) described organizational culture as complex and maintained that measuring through an inventory is not easy to accomplish and that responses only reflect personal attitudes. Another limitation was that only two individuals were surveyed in each hospital; i.e., one human resource and quality manager from sample organizations. The relationship between organizational culture and Lean Six Sigma in hospitals provides information on how specific cultural characteristics impact the Lean Six Sigma initiative key components. This information assists hospital staff who are considering implementing quality initiatives by providing an understanding of what cultural values correspond to effective Lean Six Sigma implementation.
Gutierrez-Gutierrez et al., 2016	Logistics Services	The paper identifies important implementation aspects when applying LSS to logistics services, such as CI structure, strategic analysis, cross-functional teams and process management. Furthermore, the paper discusses the potential in logistics services of the DMAIC (define, measure, analyze, improve and control) approach and tools such as value stream mapping, SIPOC (supplier, input, process, output, and customer) and process mapping	This study has two main limitations. First, the choice of only one company for the case study limits the generalizability of conclusions drawn. However, given the fact that it is set in the electronics sector, a fast evolving industry, should yet enable other companies to learn from it. Second, one of the two CIPs did not go through a complete DMAIC cycle. The paper analyzes two logistics processes where LSS has been applied – a payment process and a request-to-ship process. The analysis of both processes offers relevant information about organizational implementation in a logistics services environment about process improvement and about the use of LSS tools.
Dora M. and Gellynck, X., 2015	Confectionary	The improvement led to an increase in cycle time and a reduction of machine breakdown. Overfill was one of the prime reasons of machine downtimes because wrong package sizes or out of size specifications often causing hindrances to the machine operations.	This concept of case study has shown the benefits of the implementation of lean tool in the confectionary sector. This can be replicated in related sectors and its model can be applied in other sectors as well.
Timans, W. et al., 2016	SMEs	The results of our study are a collection of confirmations and revision proposals for the framework, leading to a revised conceptual framework	Research has certain limitations, despite the use of three research methods in triangulation. The availability of highly qualified literature focusing on CI based on LSS in SMEs is limited, and we cannot deny the fact that our focus group results are based on a single focus group session in a Dutch context.

6. Discussion

On the advent of new technology, the companies are needed to modify their practices for the sake of their survival in the market (Arain et al., 2020; Kalwar & Khan, 2020b, 2020a). Swarnakar and Vinodh, 2016 developed LSS framework in their research which provided a gateway for establishing best practice within the automotive component manufacturing organization. Lean and Six Sigma tools have been encapsulated appropriately in the DMAIC framework with proper linkage, and the framework has been executed. After successful implementation of proposed LSS framework, significant improvement has been observed with key performance metrics, such as DPU, FTY, process capability and OEE (see table 2).

Table 2. Comparison of various parameters before and after implementation of suggested methods
(source (Swarnakar & Vinodh, 2016))

Measure of process performance	Value before LSS framework	Value after LSS framework	Improvement

	implementation	implementation	
DPU	0.002	0.001	50% decrease
OEE	0.64	0.91	42.18% increase
Changeover time	470 min	400 min	14.9% decrease
FTY	0.998	0.999	0.1% increase
Manufacturing lead time	16,048.8 min	9572.8 min	40.35% decrease
Cycle time	2.954 min	2.744 min	7.10% decrease
Number of workers	21	19	Reduction of two operators
Production per day	8,000 pieces	1912000 pieces	50% increase

The successful implementation of the LSS framework brings a cultural change in the automotive component manufacturing organization. There has been 50 per cent reduction in DPU, 42.18 per cent increase in OEE, 14.9 per cent reduction in changeover time, 0.1 per cent improvement in FTY, 40.35 per cent reduction in manufacturing lead time, 7.10 per cent decrease in cycle time, 9.52 per cent decrease in manpower and 50 per cent increase in production per day for automotive component as shown in the table 5. The developed LSS framework has been implemented in case organization, and it reduces non-value-added activities and minimizes huge amount of inventory and defects. Apart from these improvements, several societal benefits have been facilitated such as change in organization culture, activities and employees behavior (Swarnakar & Vinodh, 2016).

Knap, S., 2015 examined the relationship between four organizational cultural types defined by the Competing Values Framework and three Lean Six Sigma implementation components i.e. management involvement, use of Lean Six Sigma methods and Lean Six Sigma infrastructure. In total, 104 healthcare professionals completed the questionnaire; 55 responders were quality managers and 49 were human resource managers. In total, 22 responses were from Maine; 21 from New Hampshire, 11 from Vermont, 42 from Massachusetts and eight from Rhode Island. In total, 42 percent of responders were from hospitals with one to 99 beds; 29 percent from hospitals with 100 to 249 beds, 17 percent, 250 to 400 beds and 12 percent from hospitals more than 400 beds. Responses-based hospital size and employee count were 6 percent from hospitals with one to 200 employees; 26 percent, 201 to 500 employees; 30 percent, 501 to 1,200 employees; and 38 percent were 1,200 employees or more. Most hospitals (92 percent) had quality management initiatives in place; 35 percent using a Lean Six Sigma variation. Among Lean Six Sigma organizations, 73 percent had used Lean Six Sigma for less than two years; 22 percent, three to five years; and 5 percent more than five years. The instrument section focusing on quality practices had questions addressing three Lean Six Sigma components: management support, infrastructure and methods. Three questions were specific to three components. The maximum score for each component was 15 and the minimum was 3. The mean score for the management support component was 10.2 ± 1.92. The mean score for infrastructure was 6.8 ± 2.6 and the mean score for methods was 8.3 ± 1.96. MANOVA was calculated to evaluate organizational cultural types the interactions between the organizational cultural types (group, hierarchical, developmental and rational) on the dependent (management support, infrastructure and Lean Six Sigma method). Significant effects were found on the organizational cultural types (0.01). The ANOVA on management support was significant (0.01). The ANOVA on infrastructure was not significant (0.21). The ANOVA on Six Sigma methods was not significant (0.26)(Knapp, 2015).

7. Conclusion

Literature review was conducted on one of the major lean tool i.e. Lean Six Sigma (LSS) in the context of its application and implementation in various industrial sectors. Most of the manufacturing and automotive companies, some of SMEs, food and construction companies have implemented mentioned lean tool i.e. Lean Six Sigma (LSS).Although the popularity of the Lean Six Sigma methodology has illustrated many benefits over the years for those organizations who have implemented it, this strategy has received less attention in developing countries(Albliwi et al., 2012). Due to the lack of awareness about the effectiveness and impact of lean tools, the companies are reluctant to adopt this approach. At the other hand, resistance from employees and top management are also the main hindrances in the way to this change. In this regard, one of the researcher have suggested that the employees must be taught for proper lean tools implementation from the bottom to the top in the execution(S. Singh et al., 2020).

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9. Future implications

In the present paper, one of the major lean tool i.e. Lean Six Sigma (LSS) is discussed but in the future research, other lean tools can be discussed in depth in order to put more clear and broad picture of effectiveness and loopholes. More research papers can be considered in order to draw better and effective conclusion.

10. Conflict of interest

There were no conflict of interest among the authors of the present research paper.

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