Global Journal of Research in
Engineering and Technology
Journal homepage: https://gsjournals.com/gjret/
ISSN: 2980-4205 (Online)

(Review Article)

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Lean six sigma for improving supply chain management - A literature review

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Global Journal of Research in Engineering and Technology, 2022, 01(01), 018–031

Publication history: Received on 22 August 2022; revised on 26 September 2022; accepted on 29 September 2022

Article DOI: https://doi.org/10.58175/gjret.2022.1.1.0013

Abstract

Supply chain management (SCM) is essential for any company to survive increasing global competitive pressures. SCM depends on continuous improvement and how it is implemented to support performance. Lean Six Sigma (LSS) enables supply chains to become more efficient and effective in sustaining continuous improvement. The integration of SCM and LSS is in its very initial stages. This work highlighted the most important LSS tools for improving SCM. Furthermore, a general framework for LSS-SCM is developed. This framework provides a step-by-step roadmap for improving SCM especially in manufacturing. Using this study, practitioners can determine which combination of LSS tools leads to the best performance and rapid success.

Keywords: Supply chain, SCM; LSS; TQM; Continuous Improvement; Effectiveness; Efficiency

1 Introduction

Lean Six Sigma (LSS) approach is a continuous improvement strategy that increasing process efficiency and effectiveness. As shown in Fig. (1), LSS can benefit operations management in several ways, such as improving quality rate, reducing processing time, increasing process flexibility, reducing production cost, improving customer satisfaction, among others. LSS is an approach that combines the tools and philosophies of both approaches. As shown in Fig. (2), there are four main elements for effective implementing of LSS, which are top management support, effective leadership, capable teamwork and solid infrastructure. LSS project initiatives start with understanding the current state of the business processes in organization, then setting up targets for future state of all activities. Fig. (3) shows the most common LSS tools. Using these tools and techniques organization can improve business processes., (Gomaa, 2022, Antony, 2021, Ishak, 2020).

Supply chain management (SCM) is essential for any organization to reduce costs and improve customer satisfaction. Effective SCM is crucial for business continuity as well as survival in an increasingly competitive market. As shown in Fig. (4), SCM is an integrated system for managing the flow of materials from suppliers through manufacturing and distribution chains to end customers. SCM aims to ensure that the customer gets the right product, at the right time, in the right place, at the lowest cost. In order to achieve the supply chain goal of fulfilling customer orders more quickly and efficiently than competitors, a supply chain needs to engage in continuous improvement processes and competitive strategies., (Oubrahim, 2022, Lehyani, 2021, Zhao, 2020, Vasantham, 2020).

Integrating LSS in SCM provides a competitive edge. Streamlining processes and cutting waste allows organizations to consistently deliver top-notch services, satisfying customers. SCM can utilize various LSS principles that ensure customer satisfaction and improve process efficiency and effectiveness. LSS-SCM can help streamline a company's activities to eliminate waste, reduce defects, increase value added, improve customer satisfaction, and gain a competitive advantage in the market. As shown in Fig. (5) and Fig. (6), LSS allows SCM to become more efficient and effective in maintaining continuous improvement. This synergy not only achieves operational excellence but also

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nurtures a culture of on-going improvement. In today's competitive landscape, embracing LSS in SCM is not just an option; it's a strategic necessity for success., (Basuki, 2021, Ali, 2020, Madhani, 2020, Asmae, 2019). The main objective of this study is to discuss the most important LSS tools for improving SCM. Furthermore, a general framework for LSS-SCM is developed. The paper is structured as follows: Section 2 presents a literature review, and Section 3 discusses the proposed LSS-SCM framework. Finally, Section 4 concludes with the practical lessons learned and future research opportunities.

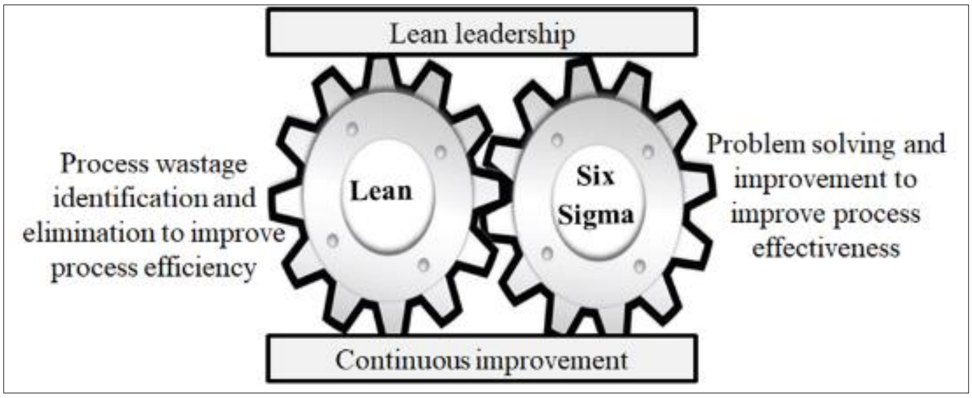

Figure 1 Lean Six Sigma Concept.

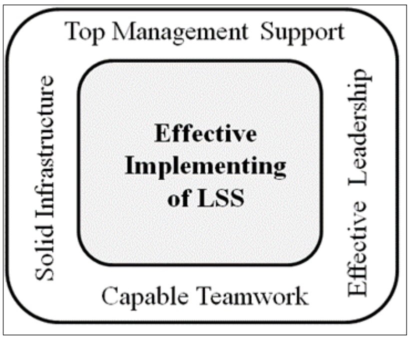

Figure 2 Main elements for effective implementing of LSS.

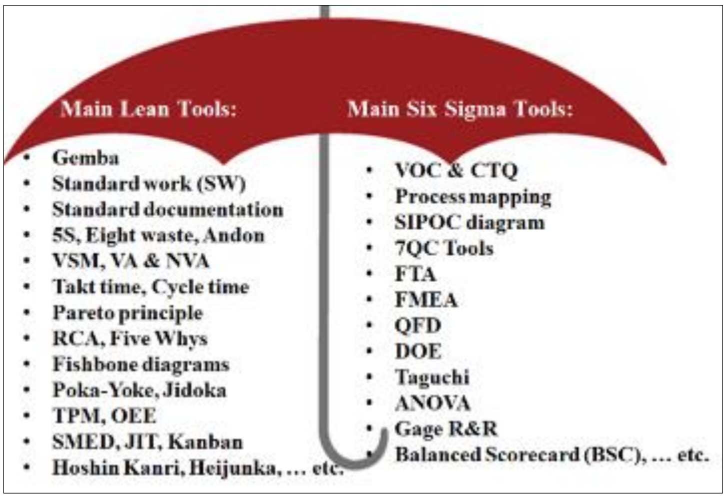

Figure 3 Main LSS tools, for example

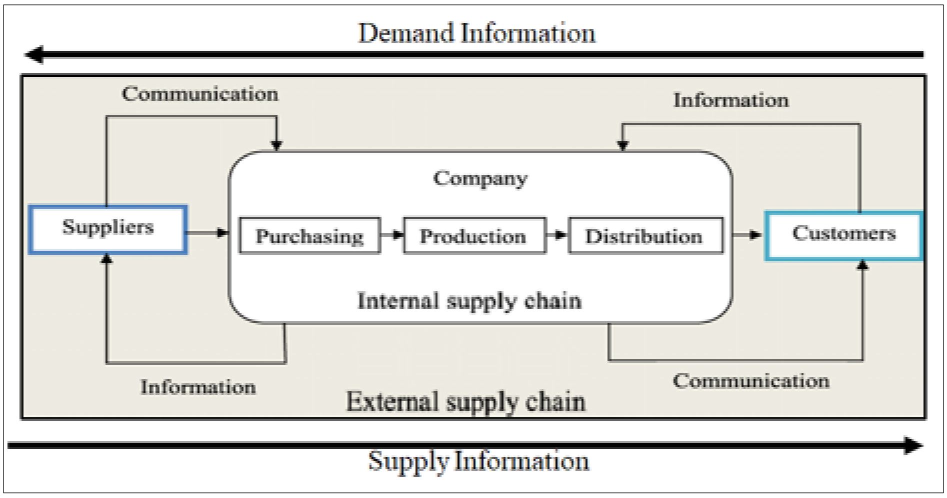

Figure 4 Supply Chain Management System, for example

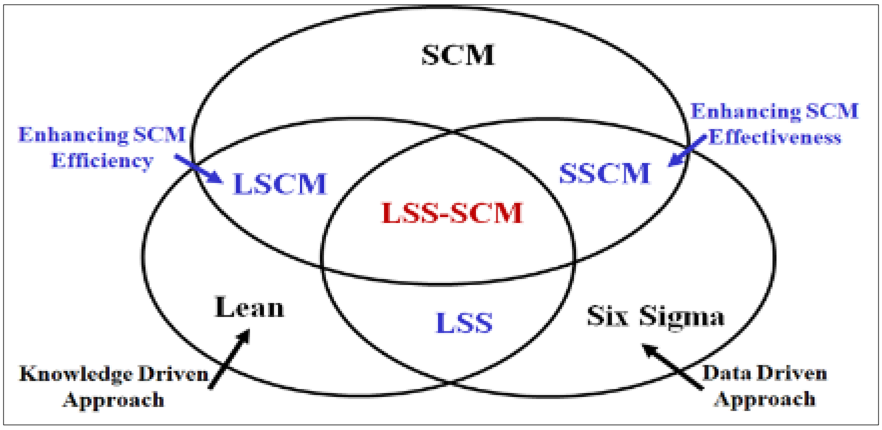

Figure 5 Conceptualization of LSS, SCM and LSS-SCM

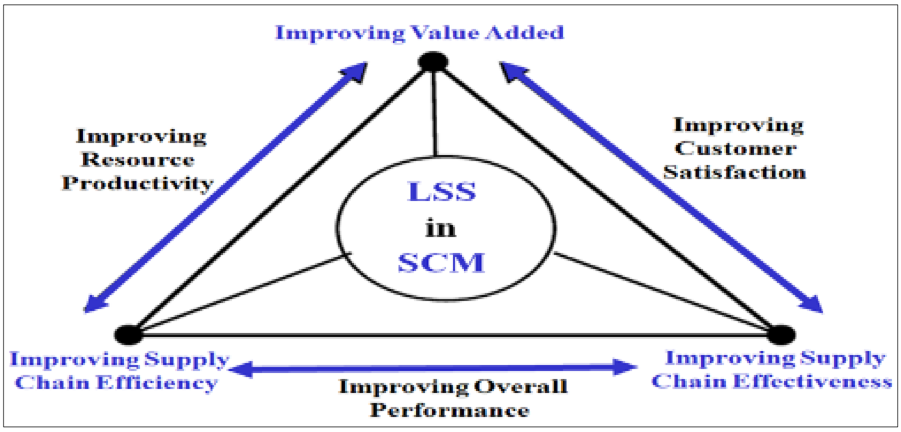

Figure 6 LSS-SCM Objectives

2 Literature review

Many studies have focused on applications of LSS in different stages of SCM. Table (1) presents a comprehensive survey of LSS-SCM studies, categorized based on contribution, application, main objectives and main LSS tools. In conclusion, the main findings of the previous literature review indicate that, applying LSS framework in SCM can improving quality, reducing process variation, eliminating waste, improving production rate, improving process productivity, reducing cycle time, reducing non-value-added time, reducing lead time, reducing production cost, reducing unit price, and increasing customer satisfaction. As a result, it is evident that each study has focused on a specific area in SCM and there is a gap in the literature regarding an integrated LSS framework in SCM. This paper makes the first attempt to propose an integrated LSS framework for enhancing SCM, it shows that LSS tools may help improve the efficiency and effectiveness of a supply chain and thus contribute to its continuous improvement process.

Literature related to both LSS and SCM was studied, especially works incorporating critical success factors (CSFs) and application of LSS in manufacturing supply chains. CSFs are a means the critical factors facing by the organization to meet the LSS-SCM goals for success. Many organizations have implemented LSS-SCM to increase SCM efficiency and effectiveness. Successful implementation of LSS-SCM in manufacturing industry depends on many critical factors. Based on the literature review, it was found that the most important success factors of LSS-SCM are as shown as follows: (Orji, 2022, Ali, 2020, Yazdi, 2020, Houti, 2019, Hariharan, 2019, Selvaraju, 2019, Yang, 2017,):

1. Management support, commitment and involvement
2. Leadership development and awareness
3. Clear strategic plan, business plan, vision and mission
4. Effective external and internal benchmarking of best practices
5. Clear goals, objectives, policies, and KPIs
6. Information quality and sharing
7. Focus on competitive priorities
8. Effective teamwork management
9. Customer engagement and satisfaction
10. Effective customer relationship management (CRM)
11. Supply chain integration
12. Effective supplier relationship management (SRM)
13. Effective market demand forecasting, planning and control
14. Effective material requirement planning and control
15. Effective inventory planning and control
16. Production system flexibility
17. Effective Organizational structure & responsibility matrix
18. Employee training, education and awareness
19. Employee attitude, skills and expertise
20. Effectives reward, recognition and motivation system
21. Effective information and communication technology
22. IT Infrastructure
23. Effective LSS-SCM software
24. Effective facility layout, configuration and planning
25. Effective project selection, planning and control system
26. Effective facility resources and infrastructure
27. Understanding LSS-SCM methodology, techniques and tools
28. Standardization of procedures and information
29. Linking LSS tools to business strategy
30. Linking LSS tools to SCM elements
31. Employee engagement, empowerment and satisfaction
32. Project success stories, best practices and benchmarking
33. Effective change management and Organizational culture
34. Financial resource capabilities
35. Economic benefits

Table 1 LSS studies in SCM elements (from 2020 to 2022), for example

Ref.	SCM Area	Contribution	Application	Main objectives	Main LSS Tools
Sharma, 2022	Operations	Proposed a LSS framework for manufacturing	A case study in an automobile manufacturing	Reducing defect % Increasing production rate	DMAIC, Mapping, Charter, VSM, 8Waste, Pareto, C&E, Sigma level.
O'Mahony, 2021	Stock	Discussed LSS tools in SCM of an operating room in a hospital	A case study in health services	Reducing stock holding value Reducing out-of-date stock	DMAIC, Charter, SMART, Mapping, SIPOC, RACI, CTQ, VOC, 5S.
Praharsi, 2021	Operations	Presented a LSS framework in SCM	A case study in maritime industry	Achieving supply chain resilience	DMAIC, 7Waste, CTQ, RCA, C&E, FMEA, Sigma level.
Tay, 2021	Logistics	Discussed LSS for digital transformations and SCM	Three logistics case studies	Achieving enterprise-wide improvements	DMAIC, Mapping, VOC, VSM, C&E, Poka-Yoke, KPIs Dashboard.
Tay, 2021	Logistics	Discussed LSS tools for logistics supplier selection	A case study in logistics services for a health-care	Improving the supplier selection process	DMAIC, Mapping, VOC, C&E, 5S, SW, KPIs Dashboard.
Kumar, 2021	Operations	Developed a LSS framework for manufacturing	A case study in an engine cylinder	Reducing defect %	DMAIC, Charter, Mapping, ABC, Pareto, Control charts, C&E.
Hardy, 2021	Operations	Presented a LSS framework for manufacturing	A case study in laminated panel production	Reducing machine downtime Improving process OEE	DMAIC, Charter, Mapping, CTQ, Takt, VSM, OEE, Charts, C&E, PDCA, FMEA.
Murmura, 2021	Operations	Developed a LSS framework for manufacturing	A case study in iron industry	Reducing lead time Reducing defect %	DMAIC, Charter, Gantt, Mapping, VSM, Sigma level, Control charts, 5Why, C&E.
Patyal, 2021	Operations	Proposed a six-sigma framework for manufacturing	A case study in a chemical company	Reducing customer complaints	DMAIC, Charter, Mapping, Cpk, 5Why, C&E.
Almutairi, 2020	Operations	Developed a LSCM framework for health-care	A case study in a hospital SCM	Improving non-added activities	TQM, VOC, Mapping, VSM, TPM, ANOVA.
Andersson, 2020	Supply chain	Proposed a six-sigma framework for supply chain risk	Case selection in seven Swedish companies	Improving the awareness and m risk	DMAIC, TQM.
Madhani, 2020	Supply chain	Presented a LSS framework in SCM	Theoretical analysis	Enhancing supply chain efficiency and effectiveness	DMAIC, 8Waste, VSM.
Liu, 2020	Operations	Presented a VSM framework for manufacturing	A case study in footwear manufacturing	Reducing defect % Reducing lead time Reducing WIP	DMAIC, VSM, Takt, DOE, Taguchi.
Nandakumar , 2020	Operations	Developed a LSS framework for manufacturing	A case study in food industry	Improving process OEE	DMAIC, Mapping, VSM, OEE, ANOVA, 5S, C&E.
Tiwari, 2020	Operations	Proposed a sustainable lean production framework	A case study in cookware manufacturing	Improving sustainability Minimizing incidents	DMAIC, Charter, KPIs, VSM, Pareto, 8Waste, C&E.

3 Proposed LSS-SCM framework

By implementing Lean Six Sigma in the supply chain, organizations can streamline their operations, reduce costs, improve product quality, and ultimately achieve higher levels of customer satisfaction. This integrated approach involves using problem-solving techniques, such as process improvement methodologies and quality management, to achieve operational excellence. The primary objective of this section is to propose a roadmap for LSS project management to improve the project effectiveness and efficiency. Based on in-depth analysis of the literature review, LSS framework was developed using various analysis and improvement tools. The SCM process typically consists of the following five phases: initiating, planning, executing, controlling, and closing. Table (2) shows the proposed LSS tools for each phase. Customer satisfaction is the core of any project and therefore must be enhanced through voice of the customer (VOC) analysis, which is a critical analysis procedure that provides accurate information regarding customer requirements. As shown in Table (3), VOC is an in-depth process of capturing customer expectations and preferences. Supply chain KPIs are performance indicators that companies use to evaluate and improve the efficiency and productivity of various supply chain operations. This visual information can be used to manage inventory, sales, shipping, suppliers, and more. Table (4) shows the proposed SCM KPIs design for the different SCM areas. Table (5) shows the proposed LSS tools for different SCM areas.

The heart of lean is the identification and elimination of waste, known in Japanese as *muda*. As shown in Table (6) and Table (7), there are eight types of waste (DOWNTIME) that an organization must remove from a value stream:

- Defects – Repair or rework and excessive scrap
- Waiting – Excessive idle time between steps
- Overproduction – Producing items not demanded by the customer
- Not utilizing talent - Skills – Unused employee creativity
- Transportation – Inefficient transport over long distances
- Inventory – Excess raw materials, work in process or finished goods
- Motion – Unnecessary worker motion when completing a task
- Excess processing - Overprocessing – Provide higher quality parts than necessary

Ensuring an error-free supply chain is pivotal. Lean methodology uses the Poka-Yoke approach, which prevents errors and ensures accurate execution of tasks. Additionally, Visual control (5S) is a Japanese organizational system that consists of five words beginning with the letter "S". These terms are Seiri (Sorting), Seiton (Setting in Order), Seiso (Shining), Seiketsu (Standardize), and Shitsuke (Sustain). The purpose of this approach is to establish an efficient and productive workspace by categorizing and storing utilized items, maintaining cleanliness and organization, and consistently upholding the established order. This system usually is the result of a discussion about standardization, which helps workers understand how the job should be done. Table (8) shows implementation of 5S in SCM process.

Finally, DMAIC (Define, Measure, Analyze, Improve and Control) methodology used in LSS is a disciplined and structured process used in solving project problems and achieving continuous improvement. If there is a problem in the process that prevents the project from producing high-quality products and services efficiently and consistently within the specified time and at low cost, LSS-DMAIC tools help identify the root cause of the defects. Table (9) shows the proposed LSS-DMAIC framework for supply chain operations. Details of the DMAIC framework are provided in the following subsections.

3.1 Define Phase

The purpose of this phase is to clarify the project scope of work and identify the objectives and problems. This phase can be summarized in the following main steps:

- Step #1: Defining scope of work and main objectives.
- Step #2: Building process improvement teamwork.

- Step #3: Defining system selection and required information.
- Step #4: Identifying Problem Statement.
- Step #5: Defining the customer requirements
- Step #6: Defining project network
- Step #7: Formulate the project plans
- Step #8: Defining process mapping.
- Step #9: Defining project supply chain.

3.2 Measure Phase

This phase aims to document and understand the current state of the system and identify important metrics related to maintenance quality and performance. This phase can be summarized in the following main steps:

- Step #10: Designing standard templates & collecting the required information.
- Step #11: Assessing the current state of design, plans, delivery, … etc.
- Step #12: Measuring the current performance evaluation.
- Step #13: Measuring the current Sigma Level.
- Step #14: Preparing the maintenance value stream mapping (Before improvement).
- Step #15: Identifying the top failures for the critical equipment

3.3 Analyze Phase

The purpose of this stage is to analyze the problems and shortcomings of the system and determine the root cause of the problems. This phase can be summarized in the following main steps:

- Step #16: Constructing risk assessment & maintenance strategies.
- Step #17: Analyzing project risk & proactive strategies.
- Step #18: Analyzing problems root causes (RCA).
- Step #19: Constructing fishbone diagram.
- Step #20: Constructing Failure Mode Effect Analysis (FMEA).

3.4 Improve Phase

This phase begins by listing the recommendations and solutions obtained during the analysis phase. This phase can be summarized in the following main steps:

- Step #21: Constructing project risk register.
- Step #22: Preparing the proposed improvement recommendations.
- Step #23: Preparing project standardization system
- Step #24: Preparing the project improvement plan

- Step #25: Training the teamwork groups.
- Step #26: Implementing kaizen & lean principles.
- Step #27: Implementing changes and monitoring progress.
- Step #28: Updating the project Value Stream Mapping (After improvement).

3.5 Control Phase

In this phase, the project team develops a control plan to monitor and maintain the improvement plan. This phase can be summarized in the following main steps:

- Step #29: Controlling before/after KPIs analysis.
- Step #30: Creating a culture of continuous improvement.
- Step #31: Documenting and standardizing the pest practice.
- Step #32: Providing advanced training and support.
- Step #33: Preparing project close-out report (annual report).
- Step #34: Communicating results & learned lessons.

In conclusion, the proposed framework will help improve supply chain performance by investigating the causes of process disruptions, thereby eliminating their root causes, leading to improved product quality, reducing lead time and improving material availability.

Table 2 Proposed LSS tools for SCM project phases (Brainstorming Session), for example

Phase	SCM Project Initiating	SCM Project Planning	SCM Project Executing	SCM Project Controlling	SCM Project Closing
Main LSS Tools	VOC CTQ RACI Benchmarking Milestones Mapping SIPOC SW	Network Gantt Master plan Action plans KPIs dashboard SMART VSM JIT Kanban RCA	Work orders QA/QC SW 5S Kaizen events JIT Kanban Poka-yoka	KPIs dashboard QC 8 wastes VSM RCA FMEA Reliability test Pareto chart Sigma level Fishbone	KPIs dashboard RACI RCA Pareto chart Rule 80/20 Fishbone Close-out report

Table 3 Voice of customer (VOC) analysis (brainstorming), for example

#	Product dimensions	Customer requirements	Main Objectives	Main LSS tools
1	Scope	Specific scope of work	Reducing scope variance	• Process mapping • SIPOC diagram • Standard work (SW)
2	Schedule	On-schedule delivery	Reducing schedule variance	• Value stream mapping (VSM) • Lean waste analysis (8 wastes) • 5S (Visual control) • Standard work (SW)
3	Quality	High quality	Improving quality ratio	• Quality control / Quality assurance • Sigma level analysis • Statistical quality control (SQC) • Pareto chart and rule 80/20 • Root cause failure analysis (RCFA) • Mistake proofing (Poka-yoka)
4	Safety	No safety incidents	Zero incidents	• Safety criticality analysis • Pareto chart and rule 80/20 • Root cause analysis (RCA) • Failure mode effect analysis (FMEA) • Mistake proofing (Poka-yoka)
5	Cost	Low project cost	Reducing cost variance	• Just in time (JIT) • Standard work (SW) • Lean waste analysis (8 wastes) • Value stream mapping (VSM)

Table 4 KPIs design for the different SCM areas, for example

#	SCM Area	Main objectives	Main KPIs	Targets
1	Sales & Market	Improving customer satisfaction	Customer satisfaction	≥ 95%
		Improving effectiveness Ratio	Effectiveness %	≥ 85%
		...	...	...
2	Final Inventory	Minimizing product stock-outs	Product stock outs %	≤ 5%
		...	...	...
3	Product Quality	Improving product quality	Quality %	≥ 95%
		Improving sigma level	Sigma level	≥ 3.0
		...	...	...
4	Operations	Improving production rate	Production rate	...
		Reducing cycle time	Cycle time	...
		Improving OEE	OEE	≥ 80%
		Improving time utilization	Time utilization	≥ 60%
		...	...	...
5	Critical Resources	Improving labor productivity	Labor productivity	...
		Improving machine productivity	Machine productivity	...
		...	...	...
6	Material Inventory	Minimizing material stock-outs	Material stock outs %	≤ 5%
		...	...	...
7	Financial	Improving profit	Profit %	≥ 20%
		Improving value added	Value added %	≥ 55%
		...	...	...
...	...	...	...	

Table 5 LSS tools for the different SCM areas

#	SCM Area	Main objectives	Main LSS Tools
1	Sales & Market	Improving customer satisfaction	VOC, CSA, 5S, SW, 5WA, C&E
		Improving effectiveness Ratio	
2	Final Product Inventory	Minimizing product stock-outs	5S, PC, ABC-XYZ, SW, Kanban, 5WA, C&E
4	Product Quality	Improving product quality	
		Improving sigma level	
5	Operations	Improving production rate	VOC, CTQ, δL, 5S, VSM, TPM, OEE, PC, Pareto, ABC-XYZ, SW, 5WA, C&E
		Improving OEE	
		Improving time utilization	
6	Critical Resources	Improving labor productivity	
		Improving machine productivity	
7	Raw Material Inventory	Minimizing material stock-outs	5S, PC, ABC-XYZ, SW, Kanban, 5WA, C&E
8	Financial	Improving profit %	5S, PC, SW, 5WA, C&E
		Improving value added %	

Table 6 SCM Lean wastes (DWONTIME) and LSS Tools

#	Waste Type	Waste Description	Main root cause	Main LSS Tools
1	Defects	Produce defective products or need to be rectified.	Lack of motivation	Pareto, ABC-XYZ, 5WA, C&E
2	Waiting	To wait unnecessarily Waiting for materials Waiting for handling	Poor coordination	VSM, TPM, OEE, 5WA, C&E
3	Over-Production	Produce more than the customer demanded	Poor production planning	PP, SW, 5WA, C&E
4	Not Utilizing Talent	Lose time, ideas, skills by ignoring employee ideas	Resistance to change	PP, SW, 5WA, C&E
5	Transportation of materials	Unnecessary transportation of materials	Poor housekeeping	5S, VSM, SW 5WA, C&E
6	Inventory Excess	Over stock of raw materials, WIP and final products	Poor material planning	Pareto, ABC-XYZ, 5WA, C&E
7	Motion of people	Perform unnecessary movements for work	Poor housekeeping	5S, VSM, SW 5WA, C&E
8	Excess Processing	More work or higher quality than required	Lack of standardization	5S, VSM, SW 5WA, C&E

Table 7 Proposed Lean 8 Wastes Auditing Checklist

Factor	Item	Check
Defects	There is a list of product defects and root causes There is a list of machine failures and root causes Production staff know all kinds of process defects Maintenance staff know all kinds of equipment failures There is always a pre-evaluation of suppliers before choosing them	
Waiting	Staff know the expected execution time for each activity There are waiting times between production activities There are waiting times between maintenance activities There are waiting times for materials and work in process There are waiting times for handling materials and products	
Over-Production	There is a production plan for each product and process There is a standard time for each product and process Unexpected delays/unnecessary downtime is recorded There is over production for any product and process There is over maintenance for any equipment	
Not Utilizing Talent	There is a job description for each production staff There is a job description for each maintenance staff The methods used by each staff meet their practical knowledge There are unused talents and skills among production staff There are unused talents and skills among maintenance staff	
Transportation	There are specific routes to transport the products Raw materials and work in process transportation Work stations are always clean and tidy to facilitate movement There is a record of all types of materials that can be transported There are very many transportation times for any product or material	
Inventory Excess	There is material plan and inventory control system Expiry dates of used materials are systematically checked Unplanned consumption of materials is recorded There is overstocked of raw materials and work in process There is overstocked of spare parts	
Motion of people	The equipment layout is organized in a logical sequence The process includes procedures for correct transportation of materials Staff have procedures for the correct handling of materials There is unnecessary movement of production staff There is unnecessary movement of maintenance staff	
Excess Processing	There is an operation planning sheet for each process There are optimal operation parameters for each process The operation sequence and times are recorded There are excessive or too frequent production activities There are excessive or too frequent maintenance activities	

Table 8 Proposed 5S Auditing Checklist

Factor	Item	Check
Sort	In the workplace, no unnecessary items are left or stored Broken, unusable or occasionally used items are stored in the storage area Equipment and machines are regularly used There are standards for removing unnecessary items, and they are followed There are standards in place for removing unnecessary items, and they are followed	
Set in order	Tools and equipment are properly located, well organized, and easily accessible There is a well-organized system for locating products and materials Labels are used to label locations, boxes, shelves, store items, … etc. There are signs of inventory management, such as FIFO, Kanban Cards, … etc. Safety equipment and supplies are in good condition and easily identifiable	
Shine	There is no dirt or dust on the floors, walls, ceilings, pipes, … etc. Participants maintain a clean environment for shelves, cabinets, racks, … etc. Cleaning tasks have been identified and are being followed up Individuals maintain the cleanliness of machinery, equipment, and other tools Cleanliness is maintained in the storage of materials, components, products, … etc.	
Standardize	Create informational displays and banners with color coding, and other markings 5S assessments, schedules and routines have been developed and are currently in use Everyone is aware of their obligations, as well as when and how they must fulfill them Procedures for maintaining the first 3S in good working order are shown Evaluations and measures are used to conduct audits regularly	
Sustain	5S tends to be a lifestyle rather than a practice Tools and parts are always properly stored Procedures for all of the above are evaluated and updated regularly Inventory controls should be strongly implemented Part of the 5S process includes rewarding and recognizing employees.	

Table 9 Proposed LSS-DMAIC framework for supply chain operations

Phase	Objectives	Key Activities	Used Tools
Define	Studying project, process, resources and problems in detail.	Defining scope of work and main objectives	Brainstorming
		Building process improvement teamwork	Brainstorming
		Defining system selection and required information	Brainstorming
		Identifying problem statement	Brainstorming
		Defining the customer requirements	Voice of customer
		Defining project network	Network
		Formulate the project plans	Gantt Chart
		Defining process mapping	Process flow chart
		Defining project supply chain	SIPOC diagram
Measure	Designing and collecting the required information.	Designing standard templates & collecting information	Brainstorming
		Assessing the current state of design, plans, delivery, … etc.	Brainstorming
		Measuring the current performance evaluation	KPIs Dashboard
		Measuring the current sigma level	Sigma level
		Preparing the project value stream mapping	VSM
		Identifying the top problems, failures and risks	Brainstorming, Rule 80/20
Analyze	Applying analysis tools and identifying root causes	Constructing risk assessment & proactive strategies	Risk assessment
		Analyzing project risk & proactive strategies	Risk matrix
		Analyzing problems root causes	Pareto chart , RCFA
		Constructing fishbone diagrams	Fishbone diagram
		Constructing Failure mode effect analysis	FMEA
Improve	Implementing solutions according to priorities	Constructing project risk register	Brainstorming
		Preparing the proposed improvement recommendations	Brainstorming
		Preparing project standardization system	SW
		Preparing the project improvement plan	Brainstorming
		Training the teamwork groups	Training program
		Implementing kaizen & lean principles	Kaizen, 5S, SW, 8 wastes
		Implementing changes and monitoring progress	Brainstorming
		Updating the project value stream mapping	VSM

Phase	Objectives	Key Activities	Used Tools
Control	Monitoring the process and achieving daily improvements	Controlling before/after KPIs analysis	KPIs, OEE
		Creating a culture of continuous improvement	Kaizen events
		Documenting and standardizing the pest practice	Auditing
		Providing advanced training and support	Brainstorming
		Preparing project close-out report	Close-out report
		Communicating results & learned lessons	Brainstorming

4 Conclusion

This work explores the interfaces of operational excellence (OPEX) and supply chain management (SCM). OPEX in an organization is the foundation for success in other functions. This paper proposes an operational excellence roadmap to improve SCM using Lean Six Sigma (LSS). The integration of SCM and LSS is in its very initial stages. This work highlighted the most important LSS tools for improving SCM. Furthermore, a general framework for LSS-SCM is developed. This framework provides a roadmap and step-by-step implementation of LSS-SCM especially in manufacturing domain. The proposed framework will help improve supply chain performance by investigating the causes of process disruptions, thereby eliminating their root causes, leading to improved product quality, reducing lead time and improving material availability. As future research, it is suggested to expand the study to include other types of organizations such as service systems. Further studies would ensure greater generalizability.

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