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Abstract

Purpose – The purpose of this paper is to explore the most common themes within Lean Six Sigma (LSS) in the manufacturing sector, and to identify any gaps in those themes that may be preventing users from getting the most benefit from their LSS strategy. This paper also identifies the gaps in current literature and develops an agenda for future research into LSS themes.

Design/methodology/approach – The following research is based on a review of 37 papers that were published on LSS in the top journals in the field and other specialist journals, from 2000 to 2013.

Findings – Many issues have emerged in this paper and important themes have cited which are: benefits, motivation factors, limitations and impeding factors. The analysis of 19 case studies in the manufacturing sector has resulted in significant benefits cited in this paper. However, many gaps and limitations need to be explored in future research as there have been little written on LSS as a holistic strategy for business improvement.

Practical implications – It is important for practitioners to be aware of LSS benefits, limitations and impeding factors before starting the LSS implementation process. Hence, this paper could provide valuable insights to practitioners.

Originality/value – This paper is based on a comprehensive literature review which gives an opportunity to LSS researchers to understand some common themes within LSS in depth. In addition, highlighting many gaps in the current literature and developing an agenda for future research, will save time and effort for readers looking to research topics within LSS.

Keywords Benefits, Lean Six Sigma, Future research, Impeding factors, Limitations, Motivation factors

Paper type Literature review

1. Introduction

In recent years, Lean and Six Sigma (LSS) have become the most popular business strategies for deploying continuous improvement (CI) in manufacturing and service sectors, as well as in the public sector. CI is the main aim for any organization in the world to help them to achieve quality and operational excellence and to enhance performance (Thomas *et al.*, 2009; Assarlind *et al.*, 2012).

Womack *et al.* (1990) defined Lean as a "dynamic process of change, driven by a set of principles and best practices aimed at continuous improvement." The root of Lean lies on Toyota Production System (TPS) which established shortly after the Second World War in 1940s in Japan by Taiichi Ohno (Womack *et al.*, 1990; Womack and Jones, 2003; Maleyeff *et al.*, 2012). As a result of the publication of the book *The Machine that Changed the World* by Womack in 1990, TPS has adopted by the Americans and known in the western countries as Lean manufacturing (Akbulut-Bailey *et al.*, 2012).

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Lean focussed on elimination of non-value added activities and waste (or "muda") in industry (Womack and Jones, 2003; Naslund, 2008). The seven wastes are: motion, overproduction, over processing, lead time, rework, inventory and defects (Chakravorty and Shah, 2012; Lee and Wei, 2009; Bhuiyan *et al.*, 2006; Vinodh *et al.*, 2011). In addition, two more types of waste have appeared in literature recently as stated by Vinodh *et al.* (2012): underutilization of people's creativity and environmental waste.

Lean also focusses on reduction of total cycle time (Drohomeretski *et al.*, 2013; Lee and Wei, 2009) and reduction of lead time (Hu *et al.*, 2008; Chen *et al.*, 2010). Lean consists of many tools and techniques for improvement such as the Kanban system, 5S, Cause and Effect analysis (C&E), Value Stream Mapping (VSM) and many others (Drohomeretski *et al.*, 2013; Chen and Lyu, 2009; Thomas *et al.*, 2009).

However, Lean still contains some challenges that face organizations such as the fundamental shift required in an organization's culture. Womack and Jones (2005) argued that the culture change is a big challenge in Lean as the implementation of Lean requires a fundamental shift in the way of stakeholders' thinking and in the nature of the relationship between them to reduce cost and waste.

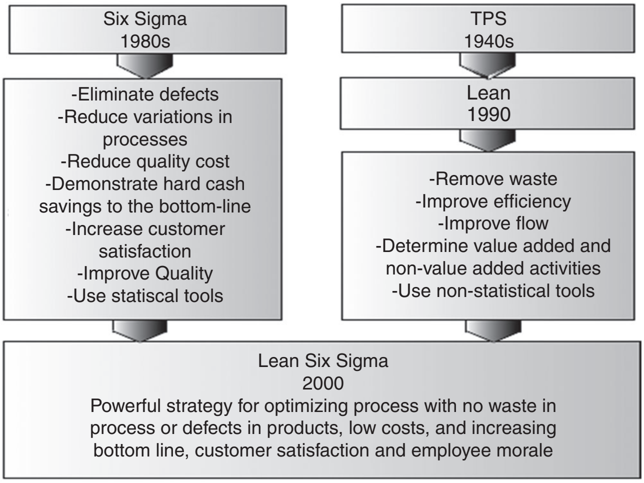
Six Sigma is defined as "a well-established approach that seeks to identify and eliminate defects, mistakes or failures in business processes or systems by focusing on those process performance characteristics that are of critical importance to customers" (Antony, 2008). Six Sigma is a statistical methodology that aims to reduce variation in any process (Chakravorty and Shah, 2012; Naslund, 2008), reduce costs in manufacturing and services, make savings to the bottom line, increase customer satisfaction (Drohomeretski *et al.*, 2013; Shah *et al.*, 2008; Manville *et al.*, 2012; Naslund, 2008), measure defects, improve product quality, and reduce defects to 3.4 parts per million opportunities in an organization (Lee and Wei, 2009; Chen and Lyu, 2009). These are done through powerful analytical and statistical tools and techniques such as Quality Function Deployment (QFD), Failure Mode and Effect Analysis (FMEA), Statistical Process Control (SPC), Design of Experiments (DOE), Analysis of Variance (ANOVA), Kano Model, etc. (Bhuiyan *et al.*, 2006). Some of these tools have adopted from TQM as Six Sigma in itself has derived from the TQM movement (Klefsjö *et al.*, 2001; Andersson *et al.*, 2006; Aboelmaged, 2010; Chiarini, 2013a, b).

Though, the high cost of Six Sigma training is a barrier for many organizations to deploy this methodology. Other disadvantages are the time it appears to take to both implement Six Sigma and for the results to become visible (Pepper and Spedding, 2010; Timans *et al.*, 2012).

In fact, deploying Six Sigma in isolation cannot remove all types of waste from the process, and deploying Lean management in isolation cannot control the process statistically and remove variation from the process (Corbett, 2011). Therefore, some companies have decided to merge both methodologies to overcome the weaknesses of these two CI methodologies when they have been implemented in isolation and to come up with more powerful strategy for CI and optimizing processes (Bhuiyan *et al.*, 2006). In fact, LSS are completing each other and there is an obvious relation between both methodologies, which makes it possible for the synergy of the two methodologies (see Figure 1) (Hu *et al.*, 2008).

Therefore, the integration of these two approaches gives the organization more efficiency and affectivity and helps to achieve superior performance faster than the implementation of each approach in isolation (Salah *et al.*, 2010).

The popularity and the first integration of LSS were in the USA in the George Group in 1986 (Chakravorty and Shah, 2012; Vinodh *et al.*, 2012). However, the term LSS was first introduced into literature around 2000 LSS teaching was established in 2003 as



Source: Adopted Shahin and Alinavaz (2008)

Figure 1.
Lean and Six Sigma integration

part of the evolution of Six Sigma (Timans *et al.*, 2012). Since that time, there has been a noticeable increase in LSS popularity and deployment in the industrial world (Shah *et al.*, 2008), especially in large organizations in the west such as Motorola, Honeywell, General Electric and many others (Timans *et al.*, 2012; Laureani and Antony, 2012) and in some small- and medium-sized manufacturing enterprises (SMEs) (Kumar *et al.*, 2006).

LSS was defined by Snee (2010) as "a business strategy and methodology that increases process performance resulting in enhanced customer satisfaction and improved bottom line results." LSS methodology aims to improve capability in an organization, reduce production costs (Lee and Wei, 2009; Chen and Lyu, 2009) and maximize the value for shareholders by improving quality (Laureani and Antony, 2012). A review of case studies has identified many reasons for organizations to implement an LSS strategy in the new millennium: for example, to improve their business performance and operational efficiency, especially in the growth of global markets, to improve product quality (Vinodh *et al.*, 2012), reduce production costs and enhance customer satisfaction (Chen and Lyu, 2009).

More recently, LSS comprises the implementation of DMAIC methodology with a mix of appropriate tools from the Lean toolkit and Six Sigma at each step of DMAIC (Kumar *et al.*, 2006; Vinodh *et al.*, 2011). Moreover, the role of DMAIC in LSS is as a framework and a solid base for successful implementation (Chakravorty and Shah, 2012). Pickrell *et al.* (2005) argued that LSS uses the Six Sigma framework as a platform for initiatives in conjunction with Lean principles and tools.

As a result of ideas about the integration of LSS and the interest in LSS by organizations, researchers have the interest to publish more papers on LSS to try to come up with a comprehensive approach to achieve CI. For instance, a number of academics have developed an integrated strategy such as the strategies that were developed by Thomas *et al.* (2008), Snee and Hoerl (2007), Pepper and Spedding (2010) and so on. Other researchers have developed a framework for the successful integration of LSS, such as Salah *et al.* (2010), Alsmadi and Khan (2010) and Kumar *et al.* (2006). The benefits and the critical success factors of applying LSS in parallel are also noted in many case study papers in both the manufacturing and the service sector (Akbulut-Bailey *et al.*, 2012; Pickrell *et al.*, 2005; Hardeman and Goethals, 2011). However, not all organizations have gained real benefits from LSS as unsuccessful implementation rendered it ineffective. In addition, there are many gaps that need to be addressed in LSS literature such as benefits, motivation factors, challenges and limitations (Pepper and Spedding, 2010; Laureani and Antony, 2011).

Hence, the purpose of this paper is to address such gaps within LSS that are most important within the manufacturing sector and allow them to achieve the most benefits from this strategy, as well as to identify the gaps and give recommendations for future research. There are also noticeable limitations in the fields of research into areas of LSS in the manufacturing sector as highlighted in this paper.

2. Methodology

To achieve the overall aims of this research, the authors are systematically reviewing the literature. According to Okoli and Schabram (2010), a systematic literature review is "a systematic, explicit, comprehensive and reproducible method for identifying, evaluating and synthesizing the existing body of completed and recorded work produced by researchers, scholars and practitioners." Tranfield *et al.* (2003) stated that systematic review has become a "fundamental scientific activity."

One of the advantages of undertaking the systematic review approach is becoming aware of the breadth of research and the theoretical background in a specific field. Researchers believe that it is very important to conduct a systematic review in any field, to understand the level of previous research that has been undertaken and to know about the weaknesses and areas that need more research in the field (Okoli and Schabram, 2010). Interestingly enough, only two systematic reviews have been published in LSS, which were carried out by Glasgow *et al.* (2010) in healthcare and the second review has been done by Prasanna and Vinodh (2013) for SMEs. In addition, a general structured review for LSS has been done by Zhang *et al.* (2012) and a few number of traditional literature reviews on LSS has appeared recently, e.g. Wang *et al.* (2012) and Ahmed *et al.* (2013).

Authors have argued that there is a clear need for more systematic reviews to be carried out in the field of LSS to bridge the gap in previous literature.

Therefore, this paper aims to present a systematic literature review of all the papers that existed in top journals and specialist journals in LSS from 2000 to 2013, to explore the most common themes that have been published in the field of LSS and to explore the gaps in each theme in the manufacturing industry. Top journals are determined by using the journal ranking list in the *International Guide to Academic Journal Quality* (ABS, 2011; Harzing 2012).

2.1 Approach and phases

In this paper, the approach includes ten fundamental processes for conducting a systematic literature review which are:

(1) Research purpose and objective: the purpose and objectives are clearly identified after a review of most common gaps that appeared in the literature.

(2) Develop research protocol: the protocol includes the study scope, strategy, criteria, quality assessment, and data extraction and so on. This protocol will be followed during the systematic literature review process.

(3) Establish relevance criteria: the research criteria help to ensure that we include only the papers most relevant to the research question, and exclude unrelated papers.

(4) Search and retrieve the literature: electronic research for relevant articles in top academic and specialist journals, and hand research in bibliography lists if needed.

(5) Selection of studies: dependent on research criteria.

(6) Quality assessment for relevant studies: using appropriate tools to assess articles for quality. Each article should be scored for its quality depending on the methodology used.

(7) Data extraction: extract the relevant data from each study included in the review.

(8) Synthesis of studies (analysis): using appropriate techniques, such as quantitative or qualitative analysis, or both for combining the extracted facts.

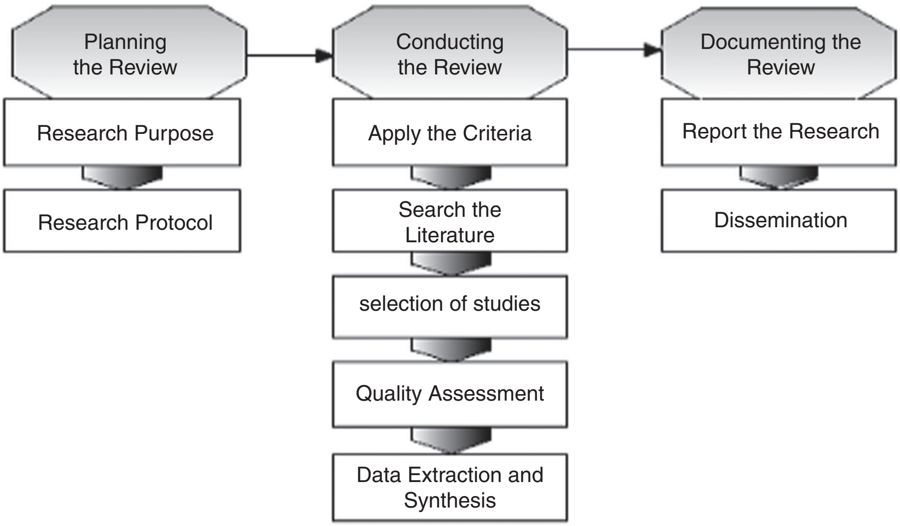
(9) Reporting: reporting the systematic literature review in detail as well as the results of the review.

(10) Dissemination: publishing the systematic review in an academic journal to make a contribution to knowledge in the field.

These processes are underlain by three phases as shown in Figure 2. The process and phases in this approach have been adapted from several academic sources such as Okoli and Schabram (2010), Tranfield *et al.* (2003) and Thomas *et al.* (2004).

2.2 Criteria

Inclusion and exclusion criteria are stated in order to make it clear to the reader why some articles with which they are familiar have been excluded from the review (Booth *et al.*, 2012).



Sources: Okoli and Schabram (2010), Tranfield *et al.* (2003) and Thomas *et al.* (2004)

Figure 2. Summary of research phases and processes

Okoli and Schabram (2010) argue that simplifying research by criteria by first reviewing the title, and then the abstract when needed, helps the researcher to save time and effort. Adopting this approach, the authors have gone through papers by title and then abstract where required, and by this means have included all papers that meet the inclusion criteria, but use of this method means that not all unrelated papers could be excluded (see Table I).

2.3 Material and outcomes

The "journal" search for research literature was done through 42 top academic journals and nine specialist journals in the field of Six Sigma, Lean and LSS that are published in nine well-known databases: Emerald, American Society for Quality (ASQ), Inderscience, Taylor & Francis, Elsevier, Informs, IEEE Xplore, John Wiley & Sons and ProQuest. Search strings have been used such as: ((lean) and (six sigma) or (lean six sigma) or (lean sigma) or (continuous improvement) and (manufacturing) and (case study) not service). Meanwhile, the literature search was limited to the English language only. However, some journals were excluded from the review due to the absence of related articles to the research criteria. This search of journals and databases illustrated that there were no research articles related to LSS to be found before 2003. This result has supported by many researchers such as Wang *et al.* (2012) who have reported that there was no LSS publication to be found before the year 2003.

The most common themes that emerged in the literature are benefits, motivation factors, limitations, impeding factors. These themes have been presented in this paper as they are the most common themes in literature (Tables II and III).

Table I.
Research criteria

Inclusion	Exclusion
Articles published between 2000 and 2012	Any publication before 2000
Articles published in two stars journals in minimum	Low-ranking journals (one star or less)
In operation management topics	Non-relevant journals
Articles published in specialists journals	
Papers highlighting benefits and motivation factors for LSS deployment in the manufacturing sector	Papers related to other sectors or other themes such as CSF, challenges, etc.
Academic journals	Books, online sites and gray literature (conferences, reports, technical reports, etc.)

Table II.
LSS specialist journals and the number of hits (papers) in each journal

Journal name and database	Start date	Entries papers	Relevant papers	Country of origins
International Journal of Lean Six Sigma	2010	24	7	UK
International Journal of Six Sigma & Competitive Advantages	2004	24	5	UK
International Journal of Productivity & Performance Management	2004	6	2	UK
Quality Management Journal (ASQ)	1993	0	0	USA
Six Sigma Forum Magazine (ASQ)	2001	9	9	USA
Quality Progress (ASQ)	1995	1	1	USA
Quality Engineering (ASQ)	2004	7	0	USA
Journal for Quality & Participation (ASQ)	1987	0	0	USA
Journal of Quality & Technology (ASQ)	1969	0	0	USA

Journal name	Entries papers	Relevant papers
International Journal of Production Research	2	0
International Journal of Production Economics	0	0
European Journal of Operational Research	0	0
Journal of the Operational Research Society	1	1
Production Planning and Control Journal	4	4
International Journal of Operations and Production Management	1	0
Manufacturing and Service Operations Management Journal	7	0
International Journal of Management Science (OMEGA)	6	0
Sloan Management Review (MIT)	7	0
Management Science	1	0
Harvard Business Review	12	0
Production and Operations Management	1	0
Journal of Operations Management	1	0
Technovation	1	0
Decision Sciences Journal	0	0
International Journal of Quality and Reliability Management	8	1
TQM Journal	7	2
Journal of Manufacturing Technology Management	3	1
Quality and Reliability Engineering International	3	1
International Journal of Technology Management	1	1
Manufacturing Engineer (IEE Transactions)	3	1
TQM and Business Excellence	2	0
European Journal of Industrial Engineering	1	1
Operations Research	0	0
Mathematics of Operations Research	0	0
Decision Analysis	0	0
Manufacturing & Service Operations Management	0	0
Interfaces	1	0
Naval Research Logistics (star journal)	0	0
Operations Research Letters	0	0
IIE Transactions	4	0
Annals of Operations Research	2	0
Mathematical Programming	0	0
Transportation Science	0	0
Journal of the American Statistical Association	2	0
Computers & Operations Research	1	0
Decision Support Systems	1	0
Academy of Management Journal	1	0
Business Process Management	1	0
British Journal of Management	0	0
California Management Review	0	0
European Business Review	0	0

Table III.
Number of Lean, Six Sigma and LSS hits (papers) in academic journals

3. Results and discussion

After a long journey and a deep review of the available literature on LSS, a number of key issues have been identified, and these are described in this section of the paper.

3.1 Growth of LSS publications in the manufacturing sector

There is a noticeable increase in the number of LSS publications in academic journals since 2003 (see Figure 3), which is the year of the first published paper on LSS in the manufacturing sector, by William and Willie, which presented the Honeywell experience in implementing LSS. While the first known integration of LSS in that sector was in 1986 in the George Group in the USA (Salah *et al.*, 2010).

As shown in Figure 3, 2012 experienced the highest number of publications with ten articles after a limited number of publications from 2003 to 2011. However, this number has dropped to two papers which were published in 2013.

Compared to other quality improvement methodologies, and to articles on LSS in other industries such as healthcare, this number of articles is quite low, but nevertheless indicates an incremental growth trend. The comparatively low volume of articles indicates that there is a crucial need for more research into LSS implementation in the manufacturing sector, especially as LSS implementation is growing rapidly in popularity in this area, as evidenced by leading corporations citing LSS as a cornerstone philosophy for their businesses. However, this low number of LSS publications is still sufficient to conduct a systematic literature review in the field of LSS. This is because there is not an agreed minimum number of papers that should be reviewed when conducting a systematic review. The authors also noticed that a number of systematic reviews have been published in academic journals and a few number of papers have been reviewed by researchers as part of the systematic literature review. For instance, Medeiros *et al.* (2011) have systematically reviewed 14 papers which met their research inclusion criteria.

3.2 Distribution of publications across the different countries

Analyzing the findings regarding the distribution of publications of LSS in the manufacturing sector across the different countries has resulted in 11 countries as shown in Figure 4. The USA has got the largest number of publications with 48.6 percent (18 papers) of the total publication. The UK and India have come in second place with almost a quarter of the number of US publications (four papers). Other countries such as Taiwan, China, Iran, etc., were found to be far behind the USA.

3.3 LSS paper themes

This section of the paper will present the most common themes using tables and figures to illustrate the results. In addition, LSS papers were found to have included different contents and themes as shown in Table IV.

3.3.1 Benefits of successful LSS implementation in the manufacturing sector. A review of 37 LSS papers showed that 19 case studies had been published in the manufacturing sector in seven different countries, which are: the USA, the UK, India,

Figure 3.
Growth of LSS publications in the manufacturing sector

the Netherlands, China and New Zealand – these are shown in Table V. The table also shows factors outside LSS as well as other tools and techniques that helped these organizations with successful implementation.

The analysis of LSS benefits in the manufacturing sector in Table V has resulted in more than 50 benefits being identified in 19 case studies. The top ten benefits cited in the papers are:

(1) increased profits and financial savings;

(2) increased customer satisfaction;

(3) reduced cost;

(4) reduced cycle time;

(5) improved key performance metrics;

(6) reduced defects;

(7) reduction in machine breakdown time;

(8) reduced inventory;

(9) improved quality; and

(10) increased production capacity.

Other soft benefits such as identifying different types of waste, development in employee morale toward creative thinking and reduction in workplace accidents as a result of housekeeping procedures also appeared in a number of cases.

In addition, analyzing the type of industry where the most LSS cases emerged showed that there is no common industry. This means that industry types vary from large industries such as aircraft manufacturing and proprietary military products to

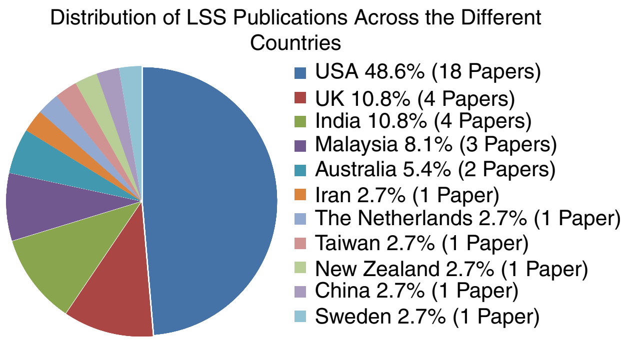


Figure 4. Distribution of publications in LSS in the manufacturing sector across different countries

Theme	No. of papers
Benefits (case studies)	19
Motivation factors	23
Impeding factors	12
Limitations	12

Table IV. LSS papers – themes in the manufacturing sector

Table V. The benefits of successful implementation of LSS in the manufacturing sector

Industry	Reasons behind implementing LSS	Tools and techniques	Benefits
Home furnishing (USA) (Chakravorty and Shah, 2012)	To change the operation to show positive results To improve employees' morale To improve product quality and manufacturing operations	SIPOC, VSM, C&E analysis, SMED, DOE, ANOVA, Pareto analysis, Poka-yoke	Improvement of manufacturing operation performance Improvement of team members' skills Improvement of production capacity Reduction in cost, cycle time, customer returns and inventory Reduction in variation and waste from operation
Aircraft manufacturing company (USA) (Akbulut-Bailey *et al.*, 2012)	To improve the competitive position in the market To increase the bottom line by reducing the cost of operations	C&E analysis, Kanban, Jidoka	Sales went from \$30m to \$205m/year Reduction in inventory, waste, production cost, labor time and cycle time Significant improvement in quality Increase in production, customer satisfaction and market share
Proprietary military products (worldwide) (Pickrell *et al.*, 2005)	To reduce production cost To reduce cycle time, customer returns backlog, support labor and inventory To increase production capacity	SIPOC, C&E analysis, DOE, SPC, process mapping, brainstorming	50% overall reduction in total cost 53% reduction in cycle time 82% reduction in customer returns backlog 32% reduction in support labor required 52% increase in production capacity 50% reduction in inventory Deeper understanding of production process
Compressor airfoil factory (USA) (Hardeman and Goethals, 2011)	To improve the efficiency of the shimming process To enhance the quality of the product	C&E analysis, FMEA	94% reduction in product defects Increased sigma value from 0.868 to 3.207 Elimination of unnecessary tooling and work area cleaned up Effective storage system has been created Significant improvement in the process efficiency Reduction in the amount of product scrapped
Small engineering company (UK) (Thomas *et al.*, 2009)	To examine the validity of a new LSS integrated approach that has been developed by the researchers in the study	5S, VSM, TPM, DOE, QFD, SPC	A potential saving over the year of £29,000 Increase in cell OEE from 34 to 55% Increase in production by 31% per hour from 15 to 25 pph. This added 2,800 additional parts per annum 12% reduction in the use of energy per annum Reduction in equipment downtime from 5 to 2% Ability to compete in the market has increased significantly Increased customer satisfaction Company product portfolio shifted to a higher-value market sector Increased awareness of statistical techniques for problem solving

(*continued*)

Industry	Reasons behind implementing LSS	Tools and techniques	Benefits
PCB manufacturer (China) (Lee and Wei, 2009)	To discover variation and waste causes in the ICT mold change process and reduce it To reduce the number of irregular pin points on a pinboard	Process mapping, C&E analysis, ANOVA, FMEA, 5S, TPM	Increase in production utilization rate from 66.77 to 92.71% within 3 months Increase in throughput by 22,500 PCBs per day Significant reduction in fixture search time, an average of 4.73-1.53 min. Decrease in erroneous pins from 72 to 11.5% within 3 months, and to 1.8% within 6 months Development of a plan for future maintenance and equipment replacement
Tire manufacturing company (India) (Bhuiyan *et al.*, 2006)	To reduce defects occurring in production	VSM, 5S, C&E analysis, root-cause analysis	Reduction in defective tires in total monthly production from 22-25 to 15% within the first month
Rotary switches manufacturing (India) (Vinodh *et al.*, 2012)	To reduce defects occurring in production and streamline process flow To increase customer satisfaction To reduce scrap and rework cost	Pareto chart, C&E analysis, VSM, control charts, DOE, Kanban, 5S, Poka-yoke	10% reduction in product defects 10% reduction in defects in each stage of key performance metrics 7% increase in first-time yield (FTY) Better customer satisfaction Reduction in machine breakdown time Increase in profit More than 50% reduction in work in process (WIP) inventory Identified 7 types of waste Increased employee morale toward creative thinking
Touch panel manufacturing (Taiwan) (Chen and Lyu, 2009)	To improve the quality of the touch panel To increase customer satisfaction regarding product price and quality To improve yield rate	VOC, C&E analysis, SIPOC, ANOVA, Pareto analysis, SPC, DOE, current state map	Reduction in defects from 32.4% to less than 15% Reduction in product cost and increase in customer satisfaction Development in LSS members' experience and knowledge of advanced statistical training such as design of experiments (DOE) since the DOE is a key success factor during the improvement phase The process capability analysis of the stamp process yielded a Cpk of 2.34 and Ppk of 2.25, implying the process has already reached a Six Sigma quality standard

(*continued*)

Table V.

Table V.

Industry	Reasons behind implementing LSS	Tools and techniques	Benefits
Automobile accessories manufacturing (India) (Kumar *et al.*, 2006)	To reduce defects occurring in the finished product To win customer loyalty To enhance the bottom line To reduce work in process inventory To reduce cost of scrap and rework	Current state map, 5S, TPM, VOC, Pareto analysis, brainstorming, DOE, control charts, FMEA	Significant financial saving of $46,500 per year due to defect reduction Reduction in machine downtime from 6 to 1% Over $33,000 saving per year due to 25% reduction in process inventory $20,000 may be saved due to the reduction in workplace accidents as a result of housekeeping procedures Key performance metrics have improved significantly (e.g. defect per unit (DPU), process capability, first-time yield (FTY), etc.). Increased overall equipment effectiveness (OEE) and thus the overall plant efficiency (OPE) Reduction in customer complaints, machine setup time, workplace accidents Total savings of around $140,000 per year
Automotive valves manufacturing (India) (Vinodh *et al.*, 2011)	To improve FTR To reduce defects occurring in the finished product and increase customer satisfaction	SIPOC, brainstorming, VOC, current state map, 5S, VSM, Pareto chart, C&E analysis, control chart, DOE, Kanban	Customer satisfaction has increased The improvement of first-time right (FTR) percentage from 98.2 to 99% would save 28,000 valves per month from rejection Significant savings have been achieved Reduction in machine breakdown time, inventory, change overtime (C/O) by 25%, and in manufacturing lead time by 18.53% 50% decrease in DPU 17.64% increase in OEE Reduction in annual movement of materials from 2,040 to 1,300 miles; hence, the material movement cost has reduced from $187,298 to $103,886 per year
Industrial cleaning equipment manufacturing (USA) (Franchetti and Yanik, 2011)	To reduce cost by 15%, reduce waste and protect revenue To achieve competitive advantage in quality and market share To increase capacity by 10%	CTQ analysis, SIPOC, brainstorming, VSM, Pareto analysis, root-cause analysis, FMEA, Kanban	$660,000 reduction in cost per year 50% reduction in work cells

(*continued*)

Table V.

Industry	Reasons behind implementing LSS	Tools and techniques	Benefits
Armaments products (USA) (Corbett, 2011)	To gain financial benefits by reducing cost and cycle time	5S, TPM, VSM, process Map, C&E analysis, XY matrix, FMEA, capability analysis, SPC, ANOVA, DOE, control charts, root-cause analysis	Improvements of 91% in quality, 70% in cost, 67% in delivery, 84% in risk $3bn cost benefit from 2001 to 2007 Won Malcolm Baldrige National Quality Award (MBNQA)
Building products (New Zealand) (Corbett, 2011)	To build niche market To gain financial benefits by reducing cost and cycle time	5S, TPM, VSM, process map, C&E analysis, XY matrix, FMEA, capability analysis, SPC, ANOVA, DOE, control charts, root-cause analysis	$28m annual saving from 2002 to 2007 Won Business Excellence Award (BX)
Honeywell International Inc. (USA) manufacturing different products from aerospace products to electronic materials (William and Willie, 2003)	To reduce final product sale prices by 50% To improve productivity capacity by double To grow the business to $1m and $250 thousands in impact To improve cash flow	Process mapping, C&E analysis, FMEA, SPC, 5S and mistake proofing	$3b in financial benefits from 1995 to 2011 $1.2b gains in 2002 as a result of waste reduction Cycle time reduced from 12 to 10 days Product travel distance reduced significantly from 300 to 14 Km Reduction in manufacturing cost by 50%
Large valve remanufacturing (USA) (Kucner, 2009)	To improve quality, reduce cost and shorten cycle time in the carrier's design and manufacture	5S, VSM, kaizen, brainstorming, root-cause analysis	Throughput of remanufacturing line nearly tripled Average component lead time was reduced from 180 to 40 days, overtime was eliminated, and cost and schedule goals were regularly achieved Quality and communication improved significantly
Automotive electronic component assembly plant (Malaysia) (Yi *et al.*, 2012)	To reduce production cost To reduce defects in production To reduce losses ($300,000) from electronic component loss	C&E analysis, Pareto chart, brainstorming, 5S, VSM, Poka-yoke, SPC	18% reduction in electronic component losses in the plant from $7,680 to $6,400 within 16 weeks of the improvement phase Significant reduction in production cost

(*continued*)

Industry	Reasons behind implementing LSS	Tools and techniques	Benefits
Printing sample boards manufacturing (USA) (Roth and Franchetti, 2010)	To meet the projected yearly demand of 200,000 boards (recently 143,400 boards/year) by reducing waste in the process and increasing production capacity through waste reduction To increase clients' competitive advantage in the printing industry	Pareto chart, E-Kanban system, SOP, check sheet	Customer demand has been met by creating better processes and improved product cost Labor cost minimized by establishing the optimal number of employees Reduce the number of defects in the production process Quality of finished goods has been improved
Gases and engineering organization (USA) (Waite, 2013)	To be leaner and more efficient To eliminate non-value added activities To increase efficiency and standardization To eliminate products and other materials that are no longer used	Current state map, spaghetti diagram, VSM, 5S, Poka-yoke	Eliminated 1,163 man hours of annual non-value added walking from a cylinder-filling process at one facility Productivity increased by 18-48%, depending on the site Variable production cost decreased by 10-35%, depending on the site Increased employee morale across the board

Table V.

home furnishing manufacturing. Hence, authors argue that this variation illustrates the success of LSS in all industry types.

Table V shows the most common tools to emerge from the cases. The top five common tools are:

(1) C&E analysis (13 case studies);

(2) VSM (12 case studies);

(3) 5S (11 case studies);

(4) DOE (eight case studies); and

(5) Pareto chart (seven case studies).

These tools and techniques have been used under the DMAIC method in almost all cases, as DMAIC is the solid basis for LSS implementation (Chakravorty and Shah, 2012). The reason behind the common use of these tools and techniques in most cases is the simplicity of these tools, especially the top three tools as they are straightforward and do not contain any statistical equations or formulas. Thomas *et al.* (2009) argued that organizations avoid deploying Six Sigma as a result of the heavy statistic and the complexity of the tools and techniques. In addition, management and employees become frightened when these tools are discussed. Hence, most of the organizations, especially in the UK and Europe, would prefer to deploy Lean tools, as they are non-statistical tools.

The authors observed a rich seam of publications stating LSS benefits in the manufacturing sector, but no studies were found reporting a failure of LSS implementation. There may be many reasons for this: businesses are presumably not keen to spend time and effort preparing studies for publication that only demonstrate failure, or it may be bias in the selection of articles for publication by the various journals, who only want to report successes. The fact remains that this is a significant omission: publication of detailed analysis of failed implementations or projects would be of great benefit to those businesses contemplating LSS implementation in the future.

3.3.2 Motivation factors for LSS implementation in the manufacturing industry. There are 17 different factors that motivate companies in the manufacturing sector to apply LSS in their organizations, as cited in Table VI. These factors have been extracted from 23 papers; most of them are case studies. Figure 5 shows top five motivation factors and the number of published papers in each factor.

In most of the cases the common reasons for deploying LSS are, to change the competitive position in the market or to stay in the competition in the international market, to increase customer satisfaction, attraction and loyalty, and to improve product quality and manufacturing operations. Other factors are to increase the bottom line and to reduce the cost of quality such as cost of poor quality, production cost and so on.

The real benefits gained in the manufacturing sector motivate other organizations in different sectors such as services and healthcare to implement LSS. Motivation factors are one of the most common themes that appeared in LSS literature.

A number of factors have appeared in few studies: for example the implementation of LSS could improve employees' morale. This factor needs to be supported by more research to explore the relation between LSS implementation and the human factor. Thomas *et al.* (2009) argued that reducing machine downtime is a big step toward reducing lead time. Hence, organizations save hard cash to the bottom line by reducing

Motivation factors	References
To change operations to show positive results	Chakravorty and Shah (2012), Thomas *et al.* (2009)
To implement continuous improvement strategies	Chakravorty and Shah (2012)
To improve employees' morale	Chakravorty and Shah (2012), Waite (2013)
To improve product quality and manufacturing operations	Chakravorty and Shah (2012), Thomas *et al.* (2008, 2009), Chen and Lyu (2009), Pickrell *et al.* (2005), Hardeman and Goethals (2011), Franchetti and Yanik (2011), Richard (2008)
To change the competitive position in the market or to stay in the competition in the international market	Chakravorty and Shah (2012), Maleyeff *et al.* (2012), Hilton and Sohal (2012), Thomas *et al.* (2008), Franchetti and Yanik (2011), Akbulut-Bailey *et al.* (2012), Corbett (2011), Roth and Franchetti (2010), Bossert (2013)
To increase the bottom line	Kumar *et al.* (2006), Thomas *et al.* (2008), Akbulut-Bailey *et al.* (2012), Corbett (2011), William and Willie (2003), Snee (2010)
To reduce cost (cost of poor quality/production cost)	Thomas *et al.* (2009), Chen and Lyu (2009), Kumar *et al.* (2006), Pickrell *et al.* (2005), Waite (2013)
To reduce customer returns backlog or support labor	Franchetti and Yanik (2011), Yi *et al.* (2012), Kumar *et al.* (2006)
To increase production capacity by reducing machine breakdown time	Thomas *et al.* (2009)
To improve process efficiency	Hardeman and Goethals (2011), Arther and George (2004), Roth and Franchetti (2010), Waite (2013)
To discover causes of variation and waste in the process	Lee and Wei (2009), Roth and Franchetti (2010)
To enhance business sustainability	Maleyeff *et al.* (2012), Pickrell *et al.* (2005)
To reduce defects in production	Bhuiyan *et al.* (2006), Vinodh *et al.* (2012), Kumar *et al.* (2006), Richard (2008), Yi *et al.* (2012)
To increase customer satisfaction, attraction and loyalty	Vinodh *et al.* (2012), Chen and Lyu (2009), Kumar *et al.* (2006), Franchetti and Yanik (2011), Arther and George (2004), Richard (2008), Snee (2010), Roth and Franchetti (2010)
To improve product/process yield rate	Chen and Lyu (2009), Thomas *et al.* (2008)
To reduce time (cycle time, lead time, etc.)	Pickrell *et al.* (2005), Corbett (2011), William and Willie (2003), Snee (2010)
To reduce inventory	Kumar *et al.* (2006), Pickrell *et al.* (2005)

Table VI.
Motivation factors for LSS implementation in the manufacturing industry

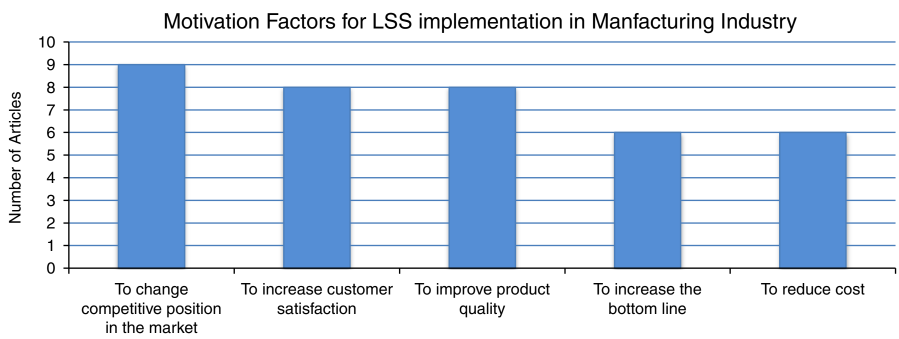


Figure 5.
Top five motivation factors for LSS implementation in the manufacturing sector

machine downtime. This view is supported by many studies, for instance Vinodh *et al.*'s (2012) case study on rotary switches manufacturing in India, Kumar *et al.*'s (2006) case study on automobile accessories manufacturing in India and many others.

In addition, authors observed that most of the organizations have been motivated to apply LSS to increase customer satisfaction or to reduce costs and to save hard cash to the bottom line. However, these organizations may not be aware of all the LSS possibilities for improvement in the different departments in their organizations. This illustrates the lack of organizations' awareness of LSS benefits. Authors argue that there is a strong relation between motivation and benefit as lack of motivation leads to fewer benefits. An organization's motivation can be increased by the use of other companies' success stories and understanding their motivation factors for deploying LSS, as well as the benefits they have gained from LSS.

3.3.3 Limitations of LSS in the manufacturing sector. Many authors have argued that there are a significant number of limitations in LSS methodology. Nine fundamental limitations were addressed in 12 papers as cited in Table VII. These limitations can be a rich area for future research.

According to Table VII, the top five limitations of LSS in the manufacturing sector are:

(1) The absence of clear guidelines for LSS in early stages of implementation.

(2) Lack of LSS curricula.

(3) Lack of understanding of the usage of LSS tools and techniques.

(4) Lack of a roadmap to be followed – which strategy first?

(5) The limited number of practical applications of LSS integrated framework.

Regarding the absence of a roadmap for LSS implementation, especially in the early stages, Kumar *et al.* (2006) argued that practitioners need a clear guide for the direction of the early stages: which strategy should come first, Lean, Six Sigma or LSS, and what tools in the toolbox should be used first. Furthermore, Kumar *et al.* (2006) observed that there is no clear understanding of the usage of LSS tools and techniques in manufacturing organizations. Hilton and Sohal (2012), Breyfogle (2008) and Salah *et al.* (2010) argued that more standardized and more robust LSS curricula are needed in order to leverage learning in organizations. Hence, developing curricula for LSS has emerged in this paper as an area for future research.

3.3.4 Impeding factors for LSS implementation in the manufacturing sector. While organizations and practitioners in the manufacturing sector are applying LSS, they face a number of complex impeding factors. These factors or challenges as cited by some authors in 12 papers are presented in Table VIII.

The last theme explored in this paper was the impeding factors for successful implementation of LSS in the manufacturing sector. The implementation of any CI program must overcome impediments, and it is valid to discuss some of the impeding factors that faced the manufacturing sector while they were implementing their LSS programs. Table VIII depicts impeding factors to LSS implementation reported by the manufacturing sector. The top six impeding factors reported are:

(1) time-consuming;

(2) lack of resources;

(3) unmanaged expectations;

Limitations	Description	Reference
No globally accepted standards for certification	Some companies have adapted the LSS certification system for themselves. This causes confusion and lack of trust in the industry	Laureani and Antony (2012), Breyfogle (2008)
Lack of emphasizing of accurate measurements for LSS implementation in literature	Timans *et al.* (2012) suggested a performance measurement system that is based on previous literature and international quality awards such as MBNQA, AQA and EQA	Chakravorty and Shah (2012)
The limited number of practical applications of LSS integrated framework	More case studies are needed to examine the integrated framework of LSS in the manufacturing sector	Vinodh *et al.* (2012), Chen and Lyu (2009)
Lack of understanding of the usage of LSS tools and techniques	Kumar *et al.* (2006) observed that there is no clear understanding of the usage of LSS tools and techniques in organizations	Kumar *et al.* (2006), Thomas *et al.* (2008), Pepper and Spedding (2010)
The absence of clear guidelines for LSS in early stages of implementation	Kumar *et al.* (2006) argued that practitioners need clear guidelines for the direction of the early stages, such as which strategy should come first, Lean, Six Sigma or LSS and which tools should be used first	Kumar *et al.* (2006), Vinodh *et al.* (2011), Thomas *et al.* (2008), Pepper and Spedding (2010)
The lack of LSS standardization curricula	Standard LSS curricula are needed in order to leverage learning in organizations (Salah *et al.*, 2010)	Hilton and Sohal (2012), Breyfogle (2008), Salah *et al.* (2010)
Lack of innovation in LSS projects	This limitation is as a result of the implementation of simple tools for improvement such as 5S, waste removal, etc. (Thomas *et al.*, 2008)	Thomas *et al.* (2008)
Lack of a roadmap to be followed – which strategy first?	This limitation can be resolved by adapting the roadmaps available in literature, depending on specific organizational needs (Snee, 2010)	Snee (2010), Kumar *et al.* (2006)
The absence of a sustainability framework for LSS	It is important to put in place a plan for sustaining the results before the start of the project implementation phase. This is a serious limitation too. How can an LSS initiative be sustainable?	Snee (2010)

Table VII. Limitations of LSS in manufacturing sector

(4) lack of awareness about LSS benefits in business;

(5) lack of training or coaching; and

(6) employee reaction towards a new business strategy.

Other factors have emerged by some authors such as convincing the top management about the benefits of LSS in business. This factor is due to a belief by top managers that investment in quality improvement programs is no more than wasting money and increasing production cost (Kumar *et al.*, 2006). Authors argue that from the results of reviewed case studies, this view cannot be true. Organizations gained massive savings to their bottom line as a result of investment in quality improvement programs.

Researchers have found that a number of factors emerged in studies by Timans *et al.* (2012), Thomas *et al.* (2008), Maleyeff *et al.* (2012), Chakravorty and Shah (2012) and Richard (2008). Lack of tangible results is one of the impeding factors reported by Timans *et al.* (2012). Researchers argue that this factor cannot be a true impediment,

Factors	Description	References
Difficulties in teaching statistical methods to some of the team members	Many LSS team members are not familiar with statistics (Chakravorty and Shah, 2012). To solve this problem, authors suggest using LSS learning games to make complex tools and techniques easy to understand	Chakravorty and Shah (2012), Thomas *et al.* (2009)
Time-consuming	One of the challenges that always faces executives in companies is the time it takes for LSS project implementation (Richard, 2008)	Richard (2008), Pepper and Spedding (2010), Smith (2003), Bossert (2013)
Internal resistance	Timans *et al.*'s (2012) survey results in SMEs showed that 54% of the respondents mentioned internal resistance as a barrier to LSS implementation	Timans *et al.* (2012), Antony *et al.* (2003)
Lack of resources	Richard (2008) stated that implementing LSS projects requires using resources. These resources are not always available in the organization; hence, this is undoubtedly a big challenge in LSS implementation	Timans *et al.* (2012), Thomas *et al.* (2008), Richard (2008)
Changing business focus	Timans *et al.*'s (2012) survey results in SMEs showed that 43% of the respondents mentioned changing business focus as a barrier to LSS implementation	Timans *et al.* (2012)
Lack of leadership	Timans *et al.*'s (2012) survey results in SMEs showed that 39% of the respondents mentioned lack of leadership as a barrier to LSS implementation	Timans *et al.* (2012), Antony *et al.* (2003)
Poor selection of projects	This can cause wasting of time, effort and resources. It also causes skepticism among many people and might kill the initiative eventually	Timans *et al.* (2012)
Lack of tangible results	All the reviewed case studies showed many positive and tangible results such as savings in bottom line, quality improvement and so on. However, Timans *et al.* (2012) argued that in some cases, the company does not get any positive results from the deployment of LSS and this impedes the company from completing LSS projects	Timans *et al.* (2012)
Lack of training or coaching	Thomas *et al.* (2008) stated that many companies have failed in LSS implementation as a result of the lack of training and knowledge of LSS tools and techniques	Timans *et al.* (2012), Breyfogle (2008), Thomas *et al.* (2008)
Unmanaged expectations	In many cases, expectations about results vary between senior managers and practitioners. This should be addressed from the very early stages of LSS implementation (Thomas *et al.*, 2008). In some cases, organizations cannot achieve the expected benefits to the bottom line (Richard, 2008) and this definitely leads the whole project to failure. Hence, the organization wastes money, time and effort with no specific improvement	Timans *et al.* (2012), Thomas *et al.* (2008), Richard (2008)
Competing projects	This relates to the selection of projects, which may be competing for implementation of resources. Managers should use appropriate criteria to select the most beneficial projects, as well as some project selection tools and techniques such as brainstorming, Critical to Quality (CTQ), focus group, Kano analysis and so on	Timans *et al.* (2012)

(*continued*)

Table VIII. Impeding factors for LSS implementation in the manufacturing sector

Factors	Description	References
Poor employee relationships	This can affect LSS implementation. It is important for LSS employees to have good relations with each other to enhance the probability of project success and make for an effective working environment	Timans *et al.* (2012)
National regulations	Both lack of regulation and overregulation put pressure on companies and prevent them being able to operate effectively within the global market (Maleyeff *et al.*, 2012)	Maleyeff *et al.* (2012)
Employee attitude toward a new business strategy	In many cases, employees think that new business strategies could put them at risk of losing their jobs if their performance is seen to be under the required level	Vinodh *et al.* (2012), Kumar *et al.* (2006), Antony *et al.* (2003)
Convincing top management	Top management often believe that investment in quality improvement programs is no more than wasting money and increasing production costs (Kumar *et al.*, 2006)	Vinodh *et al.* (2012), Kumar *et al.* (2006)
Lack of awareness about LSS benefits in business	This is one of the top challenges facing businesses, but can be tackled through training and education, as well as by getting lessons from previous successful stories of other organizations (Snee, 2010)	Kumar *et al.* (2006), Thomas *et al.* (2008), Snee (2010)
Poor organizational structure	Thomas *et al.* (2008) believe that problems in organizational structure such as financial and technical problems can limit the success of implementation of LSS	Thomas *et al.* (2008)
Lack of skills required for successful deployment	Lack of skills such as managerial, technical, statistical, etc., can be a significant barrier to LSS implementation. Without the availability of skilled members, driving a new culture into the organization could be impossible (Thomas *et al.*, 2008)	Thomas *et al.* (2008), Franchetti and Yanik (2011)

Table VIII.

because around 50 tangible results have been extracted from reviewed papers in the manufacturing sector. For instance, 50 percent of the reviewed papers stated significant increases in savings and bottom line, up to $3bn in some cases, decreased cycle time significantly by an average of 25-50 percent (as stated by Kucner, 2009, in navy-commissioned nuclear aircraft carrier in the USA, lead time was reduced from 180 to 40 days). A number of cases cited reduction in inventory and waste in processes as well as reduction in the percentage of production defects. It can, therefore, be argued that it is possibly a lack of visible results rather than a lack of tangible results that is at issue here.

Many authors such as Richard (2008) and Pepper and Spedding (2010) have argued that the implementation of LSS projects in an organization often takes too long and this is one of the challenges facing executives in organizations. Master Black Belts spend around six months or more on each LSS project and LSS projects usually take months to be completed (Smith, 2003). However, Snee (2010) argued that the implementation of LSS projects should not take more than three to six months, and this is one of the characteristics that differentiate LSS from other improvement initiatives. From the researchers' point of view, there is a clear variation in authors' opinions toward the time taken for LSS project execution. This variation could be as a result of differences in culture, LSS awareness, level of training, etc., as all these factors affect the time required for LSS implementation. Future research such as an empirical study is needed to address this gap in the literature.

4. Gaps in the current literature on LSS and agenda for future research

The following gaps have been identified by the authors in the current literature on LSS. These gaps have been grouped and prioritized as follows:

(1) Lack of a holistic approach to CI. A number of organizations select a particular approach to CI rather than taking a holistic approach to CI. For instance, some organizations choose Kaizen as its primary CI methodology, some other organizations utilize Lean as its primary CI methodology and some others choose Six Sigma as the primary CI methodology. However, there is no systematic framework currently available in the literature which guides organizations to choose a suitable CI for a given problem or scenario.

(2) Lack of standardization for certification. Although a number of companies provide training and certification on LSS, the authors would like to highlight the point that there is a clear lack of standardization for both training and certification. There is a need for the standardization of LSS curriculum for manufacturing companies (both large- and small- and medium-sized enterprises), service industries, public sector organizations and finally third sector organizations. The certification requirements (number of projects to be completed, savings generated from the project, etc.) vary significantly from one provider to another and this causes major issues in terms of developing the world class practice for LSS.

(3) Linking LSS with learning organization. Although a large number of companies have been implementing LSS as a core strategy for CI, many of them have failed to link LSS with learning organization. Some aspects of organizational learning need to be addressed such as social aspects, cultural aspects of human action, cognitive aspects, technical aspects of the work, change aspects, etc. This topic is very important for people to learn from mistakes, especially when projects fail. Failed projects are a rich source of learning, and publishing failure stories can definitely guide future research efforts in the field. For instance, at what point a LSS Black Belt and the project champion terminate a project and what are the critical factors for termination of LSS projects.

(4) LSS for SMEs. Although a large number of big organizations are deploying LSS, research has shown that very few empirical studies have been published on LSS and its current status in the context of SMEs. A number of scholars have published case studies of LSS in the context of SMEs. However, the authors would like to accentuate the point that SMEs do need a roadmap for implementing LSS and this is clearly lacking in the existing literature. Moreover, there is a desired need for the development of a LSS toolkit customized for SMEs. In addition to this, very little research has been carried out showing what kind of infrastructure is required for making LSS deployment successful in SMEs.

Other research gaps identified by the authors include:

- LSS and its link to innovation as a key driver for organizations to survive, grow and sustain competitiveness.

- LSS for enhancing supply chain performance and how long-term relationships with suppliers can improve productivity, quality and customers' satisfaction.
- LSS and environmental management system (Green LSS) to explore the relation between LSS and the environment. This will be helpful for environmental professionals to guide them on how to connect their work with LSS activities to generate better environmental and operational results.
- LSS for public sector organizations, e.g. healthcare, education, councils, police force and so on.
- LSS for high-value and low-volume environment which have not been fully understood and correctly applied such as the deployment of LSS in the aerospace manufacturing industry.
- LSS Readiness Index Model to assess the readiness of an SME to embark on a LSS journey.
- Leadership and its impact on successful deployment of LSS.

5. Conclusion

There is a noticeable increase in the popularity of LSS and level of LSS deployment in the industrial world especially in large organizations in western countries such as the USA, the UK and the Netherlands, and in some SMEs in developing countries such as India.

There are important themes cited in this paper, which are: benefits, motivation factors, limitations and impeding factors. The application of LSS methodology in 19 case studies in the manufacturing sector has resulted in significant benefits in the manufacturing sector.

The paper also explored the most commonly used tools and techniques in the case studies that were included in this research. Interestingly enough, the use of Lean tools and techniques such as VSM, 5S, etc., was more common in most cases, as these tools and techniques are non-statistical, unlike Six Sigma tools and techniques, while the use of the Six Sigma toolkit was more familiar in the American manufacturing sector than in Europe.

In addition, many gaps in the current LSS literature have been identified such as the absence of a sustainability framework of LSS and a lack of research in the relation between LSS and organizational learning. Therefore, a future research agenda for LSS has been developed in this research.

The key findings of the systematic literature review can be used by senior managers before they embark upon the LSS journey. Moreover, the findings from the research can also act as a set of guidelines (barriers, benefits, motivation, etc.) in the introduction development and implementation of LSS.

This study, as other previous studies, has limitations. One limitation is the small number of searched papers. The size of the search was due to the inclusion and exclusion criteria that were developed by the researchers to include only top-ranking journals and specialist journals in the field. Another limitation is the narrowing of the research to the manufacturing sector only – however, manufacturing is the specialist area of the researcher, and therefore an area of expertise that has enabled a greater depth of knowledge to be applied to this study. Other systematic reviews will therefore need to be conducted in the service sector, construction sector and healthcare sector in the future.

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