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A systematic literature review of Lean Six Sigma in different industries

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Abstract

Purpose – The purpose of this paper is to review Lean Six Sigma (LSS) literature and report different definitions, demographics, methodologies and industries.

Design/methodology/approach – This paper highlights various definitions by different researchers and practitioners. A total of 235 research papers has been reviewed for the LSS theme, research methodology adopted, type of industry, author profile, country of research and year of publication.

Findings – From the review, four significant LSS classifications were identified that deal with the spread of LSS in different industries followed by observation for classification.

Practical implications – LSS is a strategy for success, but it did not examine its presence in various Industries. From this paper, readers can understand the quantum of its spread before implementing LSS. For academicians, it will be a comprehensive list of papers for research.

Originality/value – This paper reviews 235 research papers for their year, author profile, research methodology and type of industry. Various characteristics of LSS definitions and their theme are also reviewed.

Keywords Management, Process, Research, Approach, Articles, Lean Six Sigma (LSS)

Paper type Literature review

1. Introduction

Lean Six Sigma (LSS) has become a popular tool to improve operational excellence in manufacturing (Albliwi *et al.*, 2015; Timans *et al.*, 2016; Prasanna and Vinodh, 2013) and other fields (Chiarini, 2012; Psychogios *et al.*, 2012a; Delgado *et al.*, 2010; Edgeman, 2010). Therefore, the study has attempted a review of the present status of LSS from 235 research articles published from 2003 to 2015 reflecting the purpose of this paper to compile the latest scenario of LSS deployment in various industries. Perhaps, from this study, it may help employees in organizations to understand the importance of LSS in determining the high success rate of the project.

2. Various definition of Lean Six Sigma found in literatures

A compilation of LSS definitions from various literature was found (shown in the Table I).

From the above definitions, it is clear that LSS is classified by various authors in different themes such as approach, methodology, model, philosophy, program strategy and system (shown in Table II).

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Sl. no.	Author(s)	LSS definitions
1	Furterer *et al.* (2005)	"LSS is an approach focused on improving quality, reducing variation and eliminating waste in an organization"
2	Kumar *et al.* (2006)	"Lean Sigma combines the variability reduction tools and techniques from Six Sigma with the waste and non-value added elimination tools and techniques from Lean Manufacturing, to generate savings to the bottom-line of an organization"
3	Heuvel *et al.* (2006)	"LSS is a program that can help healthcare providers to overcome conflicting goals. LSS is an integration of Six Sigma and Lean Manufacturing, both quality improvement programs originating from industry. Lean and Six Sigma are highly complementary. Six Sigma provides an integrated improvement approach that increases quality by reducing variation, defects, and costs. Lean adds tools that increase process throughput by eliminating waste"
4	Allen and Laure (2006)	"LSS is a recent approach to process improvement, combining the disciplines of Lean Manufacturing process improvement and Six-Sigma process improvement to gain the advantages of each discipline"
5	De Koning *et al.* (2008)	"Lean Thinking and Six Sigma are considered as separate approaches available to process innovation, with complementary strengths. When combined as LSS, this approach provides a unified framework for systematically developing innovations"
6	Chen and Lyu (2009)	"LSS technology is considered as a powerful business strategy for employing a well-structured continuous improvement methodology to effectively reduce process variability and increase quality in business processes using statistical tools"
7	Andersson *et al.* (2009)	"LSS frequently focuses on establishing and optimizing processes for activities that are repetitive in nature, as well as on driving out waste from the processes"
8	Carleysmith *et al.* (2009)	"Lean thinking and Six Sigma are now frequently used in combination, as 'Lean Six Sigma' (LSS) or 'Lean Sigma'"
9	Niemeijer *et al.* (2010)	The Lean approach seeks to convert inputs to outputs for the customer with minimum waste. Six Sigma seeks to understand how the process outputs Y relate to inputs X". "LSS is a process-focused strategy and methodology for business improvement and can be used to improve care processes, eliminate waste, reduce costs, and enhance patient satisfaction and safety"
10	Laureani and Antony (2010)	"LSS is a business improvement methodology that aims to maximize shareholders' value by improving quality, speed, customer satisfaction and costs: it achieves this through merging tools and principles from both Lean and Six Sigma"

(*continued*)

Table I.
Various connotations of LSS reported in the literature

Sl. no.	Author(s)	LSS definitions
11	Wang and Chen (2010)	"LSS approach is a popular methodology to improve the business opportunities in customer satisfaction, cost and process speed for manufacturing"
12	Lee *et al.* (2010)	"Six Sigma is a well-structured methodology that focuses on reducing variation, measuring defects and improving the quality of products, processes and services. Lean Production is an approach that focuses on reducing the cycle time and eliminating waste in processes. Combining the principles of Six Sigma and Lean can achieve synergistic results that neither system can achieve alone"
13	Niu *et al.* (2010)	"LSS aims to achieve total customer satisfaction and improved operational effectiveness and efficiency by removing waste and non-value added activities, decreasing defects, decreasing cycle time and increasing first pass yields, all resulting in a significant cost savings"
14	Snee (2010)	"LSS is a business strategy and methodology that increases process performance resulting in enhanced customer satisfaction and improved bottom-line results"
15	Atmaca and Girenes (2011)	"LSS emerges with the combination of Henry Ford's Lean Manufacturing processes in the early 1960s and the Six Sigma generated by Motorola is the last evolution step in the manufacturing history. Both applications provide to achieve operational effectiveness. This means to apply changes, adding value, to process right at the first time and to act quickly and efficiently"
16	Vinodh *et al.* (2011)	"LSS framework is scientifically designed with proper tools and techniques; proper training needs are to be provided to the team members; and quantifiable results need to be gained"
17	Johnstone *et al.* (2011)	"LSS is a well-established methodology for improving the speed, quality and cost of manufacturing and service industries"
18	Yeh *et al.* (2011)	"With a combination of Lean thinking and Six Sigma (SS), LSS is a well-known methodology for providing a powerful process improvement solution. LSS has become one of the best tools for health care system because it develops core competence in health care that deal with crucial needs in patient care and safety"
19	Manville *et al.* (2012)	"LSS is an improvement-focused approach aimed at developing and improving operational capability, its implementation can also be considered strategic, in the sense of following an approach which deals with a particular business situation or circumstance. In the next section, we consider the process of strategy development"
20	Hilton and Sohal (2012)	"LSS program involves a number of breakthrough projects that are developed by a project sponsor to significantly impact the bottom line of a business"

Table I. (*continued*)

Sl. no.	Author(s)	LSS definitions
21	Arumugam *et al.* (2012)	"LSS involves an investigator viewing a process or activities of people and/or equipment and registering, by any means (either noting down or registering in mind), for subsequent critical analysis to come to a meaningful and logical conclusion on some clues, which are the potential causes of variation in the process outcome"
22	Maleyeff *et al.* (2012)	"LSS is a system for improving the ways in which a business operates (both in its core business and within its supporting organization), LSS must be cognizant of the economic factors and external environment within which the organization competes"
23	Psychogios and Tsironis (2012)	"LSS methodology is not a standardized procedure and so it can be used in various sectors. There are a variety of methods used in order to apply the LSS, but the most characteristic is the DMAIC model"
24	Imam *et al.* (2012)	"Lean eliminates the use of Six Sigma's DMAIC cycle on the other hand, Six Sigma eliminates defects but does not address how to optimize the process flow. Hence, applying both Six Sigma and Lean tools sets results in far better improvements than could be achieved with either one method alone"
25	Zhang *et al.* (2012)	"Acting together, Lean manufacturing and Six Sigma become highly powerful and eliminate the cons of each approach. It applies the tools and techniques of both Lean manufacturing and Six Sigma"
26	Gupta *et al.* (2012)	"Six-Sigma concentrates on reducing process variation, Lean focuses on reducing process time by removing non-value-added steps and waste. When these two methodologies are combined in the form of LSS, organizations boost customer satisfaction by providing high quality products and services on time"
27	Furterer (2012)	"LSS is an approach focused on improving quality, reducing variation and eliminating waste in an organization. It is the combining of two improvement programs, Six Sigma and Lean Enterprise"
28	Silva *et al.* (2012)	"Six Sigma and Lean, acting together can become even more effective, as their strong points are able to cover the other's gaps or deficiencies. This union may create a synergy, which exercises a great influence over the general performance of the business processes"
29	Pamfilie *et al.* (2012)	"LSS has become a business model, a symbol of excellence, with the goal of eliminating waste and reducing the defects and variations in organization's processes"
30	Hors *et al.* (2012)	"The LSS program is well-known and important in the development of quality management processes of companies from different sectors"

(*continued*)

Table I.

Sl. no.	Author(s)	LSS definitions
31	Wang and Chen (2012)	"LSS is a business improvement methodology that maximizes shareholder value by achieving the fastest rate of improvement in customer satisfaction, cost, quality, process speed, and invested capital"
32	Cloete and Bester (2012)	"LSS represents a form of scientific method type, which is empirical, inductive and deductive, and system, which relies on data, and is fact-based"
33	Aguezzoul and Nyoungue (2012)	"LSS approach corresponds to the merger of two quality improvement technique: Lean and Six Sigma. Both methods encompass a number of principles and tools designed to increase process efficiency by reducing wasteful steps"
34	Wang *et al.* (2012)	"Lean and Six Sigma approaches have their own strengths and weaknesses. By combining process improvement methods with efficient process disciplines, the implementation of LSS results in reduction of delivery duration, lowering costs, and increasing customer satisfaction"
35	Gupta *et al.* (2013)	"LSS enables a company to improve both process cycle duration (efficiency and timeliness) and process quality (defect reduction). Lean Six Sigma deploys data and statistical analysis to expose the root cause of variation that results in inadequate process outputs"
36	Mousa (2013)	"LSS provides an over-arching improvement philosophy that incorporates powerful data-driven tools to solve problems and create rapid transformational improvement at lower cost"
37	Cournoyer *et al.* (2013)	"LSS program is a customer-focused, systematic approach based on utilizing data to manage and improve process performance quality"
38	Sunder (2013)	"LSS is a combination of two popular continuous improvement methodologies Lean and Six Sigma which focus typically on improving the production and transaction processes of an organization"
39	Liebtag (2013)	"LSS uses a team-driven, holistic approach to help companies simultaneously eliminate waste (that is, steps that do not add value) and increase quality"
40	Andersson *et al.* (2014)	"Joint-use strategy of LSS offers a solution that creates more flexible, robust, and cost-efficient processes"
41	Burch *et al.* (2014)	"LSS is an approach that focuses on improving the quality of finished products and continuous improvement during the creation of these products by reducing variation and eliminating non-value-add work within an organization"
42	Lighter (2014)	"LSS are typically combined with health care as they address two related, but separate, issues. Lean's concentration on cost reduction and efficiency is a perfect complement to Six Sigma's pursuits of accuracy and precision"

Table I. (*continued*)

Sl. no.	Author(s)	LSS definitions
43	Vinodh *et al.* (2014)	"LSS combines the variability reduction tools and techniques drawn from Six Sigma to the waste and non-value added elimination tools and techniques from Lean manufacturing to achieve savings in the organizations"
44	Youssouf *et al.* (2014)	"LSS is a method of improving the quality and profitability based on mastering statically of process and it is also a management style that based on a highly regulated organization dedicated to managing projects"
45	Albliwi *et al.* (2015)	"LSS has become the most popular business strategy for deploying continuous improvement (CI) in manufacturing and service sectors, as well as in the public sector"

Table I.

3. Methodology

The systematic literature review consists of three phases adopted from Tranfield *et al.* (2003). In the first phase, leading databases such as Emerald, Taylor and Francis, IEEE, Inderscience, Elsevier and Google Scholar were searched to gather papers related to LSS using keywords "Lean Sigma" and "Lean Six Sigma" dated from January 2003 to May 2015 (shown in Table III).

During the second phase, the contents of these papers were studied and classified based on their research methodology, type of industry, author profile, country of research and year of publication; medium of language used was English (Dangayach and Deshmukh, 2001; Reosekar and Pohekar, 2014). Because of myriad articles, book reviews, prefaces, editorial notes were excluded, leaving 235 relevant articles (Aboelmaged, 2010).

During the last and final phase, these papers were grouped under four classifications as journals, demography, research methodology, type of industries (shown in Figure 1). A detailed analysis of these classifications was made and tabulated in Table IV followed by discussion on these classifications with some key findings and scope for future research. The next section of the article deals with the

S. no.	LSS themes	Authors
1	Approach	Furterer and Elshennawy (2005), Allen and Laure (2006), Cournoyer *et al.* (2013), Burch *et al.* (2014)
2	Methodology	Snee (2010), Johnstone *et al.* (2011), Yeh *et al.* (2011), Psychogios and Tsironis (2012), Wang and Chen (2012), Laureani and Antony (2012)
3	Model	Psychogios and Tsironis (2012), Pamfilie *et al.* (2012)
4	Philosophy	Mousa (2013)
5	Program	Hilton and Sohal (2012), Heuvel *et al.* (2006)
6	Strategy	Chen and Lyu (2009), Niemeijer *et al.* (2010), Snee (2010), Manville *et al.* (2012)
7	System	Maleyeff (2012), Silva *et al.* (2012)

Table II.
Classification of LSS theme by different authors

S. no	Journal name	Acronym	No. of articles
1	*International Journal of Lean Six Sigma*	IJLSS	24
2	*Total Quality Management & Business Excellence*	TQMBE	22
3	*IEEE*	IEEE	12
4	*International Journal of Lean Thinking*	IJLT	11
5	*Production Planning & Control*	PPC	10
6	*International Journal of Production Research*	IJPR	10
7	*International Journal of Quality & Reliability Management*	IJQRM	8
8	*Journal of Operations Management*	JOM	8
9	*The TQM Magazine*	TQMM	7
10	*Quality Engineering*	QE	7
11	*Quality and Reliability Engineering International*	QREI	6
12	*Procedia CIRP*	PCIRP	5
13	*Procedia Engineering*	PE	5
14	*The TQM Journal*	TQMJ	5
15	*International Journal of Productivity and Performance Management*	IJPPM	4
16	*International Journal of Operations & Production Management*	IJOPM	4
17	*Benchmarking: An International Journal*	BAIJ	3
18	*International Journal of Production Economics*	IJPE	3
19	*Journal of Manufacturing Technology Management*	JMTM	3
20	*Journal for Healthcare Quality*	JHQ	3
21	*Total Quality Management*	TQM	3
22	*International Journal of Six Sigma and Competitive Advantage*	IJSSCA	2
23	*Procedia - Social and Behavioural Sciences*	PSBS	2
24	*Computers in Industry*	CI	2
25	*Drug Discovery Today*	DDT	2
26	*Journal of Industrial Engineering and Management*	JIEM	2
27	*Robotics and Computer-Integrated Manufacturing*	RCIM	2
28	*South African Journal of Industrial Engineering*	SAJIE	2
29	*Business Process Management Journal*	BPMJ	2
30	*Global Business and Organizational Excellence*	GBOE	2
31	*Journal of Operational Research Society*	JORS	2
32	*Leadership in Health Services*	LHS	2
33	*Physics Procedia*	PP	2
34	*Technology Management*	TM	2
35	*Academy of Management Executive*	AME	1
36	*Academy of Management Perspectives*	AMP	1
37	*ACS Combinatorial Science*	ACSCS	1
38	*African Journal of Business Management*	AJBM	1
39	*Alexandria Engineering Journal*	AEJ	1
40	*American Journal of Business*	AJB	1
41	*American Journal of Industrial and Business Management*	AJIBM	1
42	*Annals of Diagnostic Pathology*	ADP	1
43	*Annals of Emergency Medicine*	AEM	1
44	*Annals of Operations Research*	AOR	1
45	*Arab Journal for Science and Engineering*	AEBJ	1
46	*Asian Journal on Quality*	AJQ	1
47	*Business Horizons*	BH	1
48	*Chemical Engineering Research and Design*	CERD	1
49	*Decision Sciences Journal of Innovative Education*	DSJIE	1

(*continued*)

Table III.
LSS literature – journal-wise distribution

S. no	Journal name	Acronym	No. of articles
50	*Drug Discovery World*	DDW	1
51	*Einstein (São Paulo)*	ETN	1
52	*Engineering Systems Management and its Applications*	ESMAA	1
53	*Environmental Quality Management*	EQM	1
54	*Global Journal of Researches in Engineering Mechanical*	GJREMME	1
55	*Industrial Management & Data Systems*	IMDS	1
56	*Information and Knowledge Management*	IKM	1
57	*Interdisciplinary Journal of Contemporary Research in Business*	IJCRB	1
58	*International Journal for Quality research*	IJQR	1
59	*International Journal of Applied Engineering Research*	IJAER	1
60	*International Journal of Automotive Technology*	IJAT	1
61	*International Journal of Business and Management*	IJBM	1
62	*International Journal of Business Continuity and Risk Management*	IJBCRM	1
63	*International Journal of Construction Management*	IJCM	1
64	*International Journal of Engineering and Technology*	IJET	1
65	*International Journal of Engineering, Science and Technology*	IJEST	1
66	*International Journal of Logistics and Research Applications*	IJL	1
67	*International Journal of Logistics Research and Applications*	IJLRA	1
68	*International Journal of Scientific & Engineering Research*	IJSER	1
69	*International Journal of Supply Chain management*	IJSCM	1
70	*International Journal of Technical Research and Applications*	IJTRA	1
71	*Journal of Chemical Health and Safety*	JCHS	1
72	*Journal of Cleaner Production*	JCP	1
73	*Journal of Emergency Medicine*	JEM	1
74	*Journal of Facilities Management*	JFM	1
75	*Journal of Management History*	JMH	1
76	*Journal of Mechanical Engineering*	JME	1
77	*Journal of Service Science and Management*	JSSM	1
78	*Journal of Systems and Software*	JSS	1
79	*Management Decision*	MD	1
80	*Managerial Auditing Journal*	MAJ	1
	Total		235

Table III.

result of the literature classification. Followed by identification of gaps, scope for future research, limitations and conclusion of this study.

4. Results and discussion

4.1 Time distribution of Lean Six Sigma articles

In 1986, the George Group in the USA were first to integrate LSS in the manufacturing sector (Salah *et al.*, 2010). But the technique got popularized after 2003 (Albliwi *et al.*, 2015). There is a considerable rise in the number of LSS publications in academic journals since 2005 (Figure 2). As shown in Figure 2, 2012 witnessed the highest number of publications, with 47 articles followed by 2013. In the past five years (2011 to 2015), 149 articles on LSS have been published. On the other hand, only 101 articles were published from 1999 to 2010. This proves that the inclination toward LSS has increased considerably.

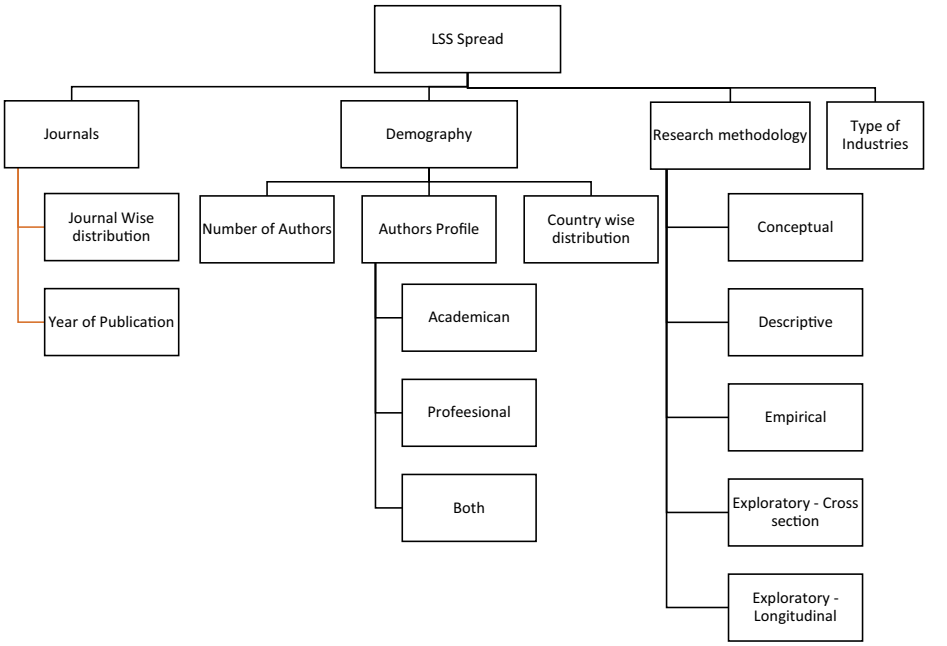

Figure 1.
Literature classification

4.2 Distribution of publications across the different countries

The study shows the spread of LSS publications across the different countries; around 36 countries with single authorship and 22 with multiple countries (shown in Table IV). Out 235 articles, 120 articles were contributed by USA, topping the list, followed by the UK and India. Other countries such as Malaysia, The Netherland, etc., were found behind India (shown in Figure 3).

Out of 235 articles, 164 articles (69.79 per cent) were contributed by academicians, 29 articles (12.34 per cent) were contributed by professionals and 42 articles (17.87 per cent) were contributed by both academicians and professionals together (shown in Figure 4) (Bhamu and Sangwan, 2014).

4.3 Analysis of research methodology

For this study, the articles were classified using the Research methodology proposed by Reosekar and Pohekar (2014). Out of 235 articles, 57 articles were qualitative and 178 were quantitative. Most of the articles follow empirical approach methodologies. Jasti and Kodali (2014) report that most of the theory building is taking place through the procedure of conceptual approach methodologies, whereas only a few follow the empirical approach methodologies. The focus of researchers should now be on creating and testing a new hypothesis with the aid of techniques like case studies and surveys, etc.

Thomas *et al.* (2014) have reported the importance of empirical research and its effects on operations management. Empirical means, defined as "knowledge obtained from real-world observations and trial", are used here to describe field-based study which gathers data from naturally occurring circumstances rather than the laboratory

S. no.	Year	Authors	Demography Profile of authors	Country	Methodology	Type of industries
1	2003	Pavnaskar *et al.*	Academic	USA	Descriptive	Manufacturing
2	2003	Pojasek	Professional	USA	Descriptive	–
3	2003	Prince and Kay	Academic	UK	Empirical	Manufacturing
4	2003	Sharma	Professional	USA	Descriptive	–
5	2004	Antony	Academic	UK	Empirical	Service industry
6	2004	Brown *et al.*	Both	USA	Empirical	Real estate
7	2004	Bruun and Mefford	Academic	Denmark, USA	Descriptive	IT
8	2005	Arnheiter and Maleyeff	Academic	USA	Conceptual	–
9	2005	Antony *et al.*	Academic	USA, UK	Empirical	Manufacturing
10	2005	Banuelas *et al.*	Both	UK	Empirical	Film-coating process
11	2005	Bhuiyan and Baghel	Academic	Canada	Descriptive	–
12	2005	Friel	Academic	Argentina	Descriptive	Manufacturing
13	2005	Furterer and elshennawy	Academic	USA	Empirical	Local government
14	2005	Heuvel *et al.*	Both	The Netherlands	Empirical	Hospital
15	2005	Melton	Professional	UK	Descriptive	Chemical industry
16	2005	Seth and Gupta	Academic	India	Empirical	Automobile
17	2005	Thompson	Academic	US	Descriptive	Military organization
18	2006	Allen and Laure	Professional	USA	Conceptual	–
19	2006	Andersson *et al.*	Academic	Sweden	Empirical	–
20	2006	Braglia *et al.*	Academic	Italy	Empirical	Electro-domestic manufacturing
21	2006	Dahlgaard and Dahlgaard-Park	Academic	Sweden	Conceptual	–
22	2006	De Koning *et al.*	Both	The Netherlands	Expl. Cross section	Healthcare
23	2006	Emiliani	Academic	USA	Empirical	Automotive
24	2006	Houshmand and Jamshidnezhad	Both	Iran	Empirical	Manufacturing
25	2006	Kumar *et al.*	Academic	UK, India	Empirical	Automobile accessories
26	2006	Liker and Morgan	Both	USA	Empirical	–
27	2006	Bendell	Academic	UK	Descriptive	–
28	2007	Antony *et al.*	Academic	UK	Ex. Longi	Manufacturing
29	2007	Chakrabarty and Tan	Academic	Singapore	Descriptive	Service industry
30	2007	Crino *et al.*	Professional	USA	Empirical	Army
31	2007	Rivera and Chen	Academic	USA	Descriptive	Manufacturing
32	2007	Savolainen and Haikonen	Both	Finland	Empirical	Electronic supplier & vehicles manufacturing
33	2007	Tang *et al.*	Both	Singapore	Empirical	–
34	2008	Bunce *et al.*	Academic	USA	Empirical	Canning industry
35	2008	De Koning *et al.*	Academic	The Netherlands	Empirical	Financial service industry
36	2008	Garcia-Porres *et al.*	Professional	USA	Empirical	Healthcare
37	2008	Hammond and Donnell	Professional	UK	Expl. Cross section	Healthcare
38	2008	Hu *et al.*	Both	USA	Empirical	Semiconductor manufacturing
39	2008	McNary	Academic	USA	Empirical	Government office
40	2008	Näslund	Academic	USA	Descriptive	–
41	2008	Nonthaleerak and Hendry	Academic	Thailand, UK	Empirical	Industrial supplies, air conditioning, medical equipment
42	2008	Pham *et al.*	Academic	UK	Empirical	Manufacturing

(*continued*)

Table IV.
LSS spread – classification

S. no.	Year	Authors	Demography Profile of authors	Country	Methodology	Type of industries
43	2008	Schroede *et al.*	Academic	USA	Empirical	Manufacturing, service
44	2008	Serrano *et al.*	Academic	Spain	Empirical	Manufacturing
45	2008	Shah *et al.*	Academic	USA	Empirical	Manufacturing
46	2008	Thomas *et al.*	Both	UK	Conceptual	Manufacturing
47	2008	Zu *et al.*	Academic	USA	Expl. Cross section	–
48	2009	Andersson *et al.* Augusto Cauchick *et al.*	Professional	UK, Sweden	Descriptive	Pharmaceutical industry
49	2009	Miguel and Marcos Andrietta	Both	Brazil	Ex. Longi	–
50	2009	Barton and Thomas	Academic	UK	Empirical	Manufacturing
51	2009	Braglia *et al.*	Academic	Italy	Empirical	Helmet manufacturing plant
52	2009	Buesa	Academic	UK	Expl. Cross section	Histolabs
53	2009	Carleysmith *et al.*	Professional	UK	Descriptive	Pharmaceutical industry
54	2009	Chakravorty	Academic	USA	Empirical	Network technology company
55	2009	Chen and Lyu	Academic	Taiwan	Empirical	Touch panel manufacturing
56	2009	Dickson *et al.*	Academic	USA	Expl. Cross section	Hospital
57	2009	Douglas Sears	Professional	USA	Empirical	Healthcare
58	2009	He *et al.*	Academic	China, USA	Empirical	Chemical industry
59	2009	Kaushik and Khanduja	Academic	India	Empirical	Thermal power plant
60	2009	Lee *et al.*	Academic	Taiwan	Empirical	Printed circuit board company
61	2009	Nakhai and Neves	Academic	USA	Empirical	Service industry
62	2009	Pettersen	Academic	Sweden	Conceptual	–
63	2009	Scherrer-Rathje *et al.*	Academic	Switzerland, Canada	Empirical	Food processing machines manufacturing
64	2009	Soković *et al.*	Academic	Slovenia, Montenegro	Descriptive	–
65	2009	Wan and Chen	Both	USA	Ex. Longi	IT
66	2010	Abuthakeer *et al.*	Academic	India	Empirical	Motor manufacturing
67	2010	Alsmadi and Khan	Academic	UK	Ex. Longi	Manufacturing
68	2010	Chen *et al.*	Academic	USA	Empirical	Electrical manufacturing
69	2010	Delgado *et al.*	Academic	Portugal	Empirical	Financial service industry
70	2010	Eswaramoorthi *et al.*	Academic	India	Empirical	Manufacturing
71	2010	Jeyaraman and Kee Teo	Both	Malaysia	Empirical	Electronic manufacturing service industry
72	2010	Jones	Academic	USA	Conceptual	–
73	2010	Kanakana *et al.*	Academic	South Africa	Empirical	Engineering education institution
74	2010	Kothari	Academic	India	Descriptive	Manufacturing
75	2010	Laureani and Antony	Both	Ireland, UK	Empirical	Service industry
76	2010	Laureani and Antony	Academic	UK	Empirical	Call centre

Table IV.

(*continued*)

S. no	Year	Authors	Demography Profile of authors	Country	Methodology	Type of industries
77	2010	Lee *et al.*	Professional	Taiwan	Empirical	Printed circuit board company
78	2010	Mahesh and Prabhuswamy	Academic	India	Empirical	Soap manufacturing
79	2010	Murata and Katayama	Academic	Japan	Empirical	Manufacturing
80	2010	Niemeijer *et al.*	Academic	The Netherlands	Empirical	Healthcare
81	2010	Niu *et al.*	Academic	USA, Hong Kong	Descriptive	Computer manufacturing
82	2010	Pepper and Spedding	Academic	Australia	Descriptive	–
83	2010	Roth and Franchetti	Academic	USA	Empirical	Printing industry
84	2010	Salah	Academic	Canada	Descriptive	–
85	2010	Snee	Professional	USA	Descriptive	–
86	2010	Wang and Chen	Academic	Taiwan	Empirical	Banking industry
87	2011	Atmaca and Girenes	Both	Turkey	Empirical	White goods manufacturing
88	2011	Cima *et al.*	Both	USA	Empirical	Healthcare
89	2011	Cunha *et al.*	Both	Brazil	Empirical	Software development for Mobile phones
90	2011	Corbett	Academic	USA & New Zealand	Descriptive	Manufacturing
91	2011	Divakaran and Kumar	Professional	India	Descriptive	Manufacturing
92	2011	Eroglu and Hofer	Academic	USA	Empirical	Manufacturing
93	2011	Furterer	Professional	USA	Empirical	Healthcare
94	2011	Gijo *et al.*	Both	UK, India	Empirical	Automobile part manufacturing
95	2011	Helmold	Professional	Germany	Expl. Cross section	–
96	2011	Hodge *et al.*	Academic	USA	Empirical	Textile industry
97	2011	Holden	Academic	USA, Sweden	Descriptive	Healthcare
98	2011	Johnstone *et al.*	Professional	UK, Sweden	Descriptive	Drug discovery environment
99	2011	Staats *et al.*	Academic	USA, UK	Empirical	Software service provider
100	2011	Sitorus	Academic	Indonesia	Empirical	Telecom industry
101	2011	Van der Meulen *et al.*	Both	The Netherlands, Belgium	Empirical	Hospital
102	2011	Vinodh *et al.*	Both	India, USA	Empirical	Automotive valves manufacturing
103	2011	Yeh *et al.*	Both	Taiwan	Empirical	Hospital
104	2012	Aguezzoul and Nyoungue	Academic	France	Descriptive	Hospital
105	2012	Alves *et al.*	Academic	Portugal	Empirical	–
106	2012	Anvari and Moghimi	Academic	Iran, Malaysia	Descriptive	–
107	2012	Arumugam *et al.*	Academic	UK	Empirical	Airport security service
108	2012	Bakri *et al.*	Academic	Malaysia	Descriptive	Manufacturing
109	2012	Bilgen and Şen	Academic	Turkey	Empirical	Automotive industry
110	2012	Box and Woodall	Academic	USA	Descriptive	–
111	2012	Cheng and Chang	Academic	Taiwan	Empirical	Non-profit organization
112	2012	Chiarini	Professional	Italy	Empirical	Healthcare
113	2012	Cloete and Bester	Both	South Africa	Empirical	Veterinary Laboratory

(*continued*)

Table IV.

S. no.	Year	Authors	Demography Profile of authors	Country	Methodology	Type of industries
114	2012	Dave and Sohani	Academic	India	Descriptive	–
115	2012	Easton and Rosenzweig	Academic	USA	Empirical	–
116	2012	Eberts	Academic	USA	Empirical	Semiconductor manufacturing
117	2012	Gnanaraj *et al.*	Academic	India	Ex. Longi	Manufacturing
118	2012	Gowen *et al.*	Academic	USA	Empirical	Healthcare
119	2012	Gupta *et al.*	Academic	India	Empirical	Radial tyres manufacturing
120	2012	Habidin and Yusof	Academic	Malaysia	Expl. Cross section	Automotive industry
121	2012	Hilton and Sohal	Academic	Australia	Empirical	–
122	2012	Hors *et al.*	Professional	Brazil	Empirical	Hospital
123	2012	Imam *et al.*	Academic	Saudi	Empirical	Automobile
124	2012	Jayaraman *et al.*	Academic	Malaysia	Empirical	Electronic manufacturing service industry
125	2012	Laureani and Antony	Academic	UK	Expl. Cross section	Manufacturing, service
126	2012	Maleyeff *et al.*	Academic	USA	Conceptual	–
127	2012	Manville *et al.*	Academic	UK, New Zealand, Australia	Ex. Longi	Digital document management service
128	2012	Pamfilie *et al.*	Academic	Romania	Empirical	Service industry
129	2012	Panizzolo *et al.*	Both	Italy, India	Empirical	Manufacturing
130	2012	Psychogios and Tsironis	Academic	Greece	Empirical	Airline industry
131	2012	Rahani and Al-Ashraf	Academic	Malaysia	Empirical	Manufacturing
132	2012	Rajenthirakumar *et al.*	Academic	India	Empirical	Textile machinery manufacturing
133	2012	Senthil Kumar and Sampath	Academic	India	Empirical	T-shirt production industry
134	2012	Shafer and Moeller	Academic	USA	Empirical	–
135	2012	Shahada and Alsyouf	Academic	UAE	Empirical	Manufacturing
136	2012	Silich *et al.*	Professional	USA	Empirical	Hospital
137	2012	Silva *et al.*	Both	Brazil	Empirical	Hospital
138	2012	Silva *et al.*	Academic	Sri Lanka	Empirical	Apparel industry
139	2012	Suárez and Ramis	Academic	Mexico	Conceptual	Service Industry
140	2012	Swink and Jacobs	Academic	USA	Empirical	Manufacturing, service
141	2012	Wang and Chen	Academic	China	Empirical	Flat Panel display equipment manufacturing
142	2012	Wang *et al.*	Both	Italy, Australia, Ireland	Empirical	Software/IT
143	2012	Wang *et al.*	Academic	China	Conceptual	Banking sector
144	2012	Wang *et al.*	Academic	China	Empirical	Manufacturing
145	2012	Weller *et al.*	Professional	USA	Empirical	Drug discovery environment
146	2012	Wong *et al.*	Academic	Malaysia	Empirical	Semiconductor manufacturing
147	2012	Zhang *et al.*	Academic	China	Empirical	Telecommunication company
148	2012	Zhang *et al.*	Academic	China, Australia	Descriptive	–
149	2012	Zhao *et al.*	Academic	China	Empirical	Manufacturing

Table IV.

(*continued*)

S. no.	Year	Authors	Demography Profile of authors	Country	Methodology	Type of industries
150	2012	Zhou	Academic	USA	Descriptive	Manufacturing
151	2013	Ahmed	Professional	Egypt	Descriptive	–
152	2013	Alemi and Akram	Academic	Iran	Empirical	Garage equipment manufacturing
153	2013	Ashok Sarkar *et al.*	Professional	India	Empirical	Insurance company
154	2013	Ashok Sarkar *et al.*	Both	India	Empirical	Insurance sector
155	2013	Assarlind *et al.*	Both	Sweden	Empirical	Manufacturing
156	2013	Aziz and Hafez	Academic	Egypt	Empirical	Construction industry
157	2013	Begam *et al.*	Academic	India	Ex. Longi	Manufacturing
158	2013	Cournoyer *et al.*	Professional	USA	Expl. Cross section	Healthcare
159	2013	Duarte and Cruz-Machado	Academic	Portugal	Empirical	–
160	2013	Enoch	Academic	Nigeria	Ex. Longi	Manufacturing
161	2013	Franchetti and Barnala	Academic	USA	Empirical	Recycling industry
162	2013	Gnoni *et al.*	Both	Italy	Empirical	Automotive supplier firm
163	2013	Goh	Academic	Singapore	Descriptive	–
164	2013	Gupta *et al.*	Academic	India	Empirical	Radial tyres manufacturing
165	2013	Habidin and Yusof	Academic	Malaysia	Empirical	Automobile
166	2013	Kabir *et al.*	Academic	Bangladesh	Empirical	Fan manufacturing
167	2013	Karthi *et al.*	Both	India	Empirical	Textile mill
168	2013	Kim	Academic	Philippines	Empirical	Donuts company
169	2013	Kornfeld and Kara	Academic	Australia	Descriptive	–
170	2013	Krogstie and Martinsen	Academic	Norway	Empirical	Manufacturing
171	2013	Kumar	Academic	India	Empirical	Automobile
172	2013	Lee *et al.*	Academic	Taiwan	Empirical	Logistics centre
173	2013	Liebtag	Professional	USA	Descriptive	Rea & Associates Accounting Industry
174	2013	Dlamini and Waveren	Academic	South Africa	Conceptual	Technology environment
175	2013	Matt and Rauch	Academic	Italy	Empirical	Manufacturing
176	2013	Meza and Jeong	Professional	USA	Empirical	Johnson space center, government sector
177	2013	Mostafa *et al.*	Academic	Australia, Egypt	Conceptual	Manufacturing
178	2013	Mousa	Academic	India	Descriptive	–
179	2013	Nicoletti	Academic	Italy	Descriptive	–
180	2013	Niemeijer *et al.*	Both	The Netherlands	Expl. Cross section	Healthcare
181	2013	Noorwali	Professional	Saudi	Empirical	Food industry
182	2013	Powell *et al.*	Academic	Norway	Empirical	Manufacturing and service supplier
183	2013	Rantamäki *et al.*	Both	Finland	Empirical	Pulp and paper manufacturing industry
184	2013	Rizvi	Academic	USA	Empirical	University laboratory
185	2013	Shamah	Academic	Egypt	Expl. Cross section	Manufacturing
186	2013	Sultana and Islam	Both	Bangladesh	Empirical	Apparel industry
187	2013	Susilawati *et al.*	Academic	UK	Conceptual	Manufacturing

(*continued*)

Table IV.

S. no.	Year	Authors	Demography Profile of authors	Country	Methodology	Type of industries
188	2013	Sunder	Professional	India	Descriptive	Transaction-based service organization
189	2013	Vylen *et al.*	Both	India	Empirical	Automotive component manufacturing
190	2013	Wong *et al.*	Academic	Singapore	Empirical	Aircraft spare management company
191	2014	Albliwi *et al.*	Academic	UK and Netherland	Empirical	–
192	2014	Anderson and Kovach	Academic	USA	Empirical	Construction
193	2014	Andersson *et al.*	Both	Sweden, Finland	Empirical	Telecom manufacturing
194	2014	Arunagiri and Gnanavelbabu	Academic	India	Empirical	Automobile industry
195	2014	Assarlind and Aaboen	Academic	Sweden, Norway	Empirical	Manufacturing
196	2014	Banawi and Bilec	Academic	USA	Empirical	Construction Industry
197	2014	Belekoukias *et al.*	Academic	UK	Empirical	Manufacturing
198	2014	Besseris	Academic	USA	Empirical	Food industry
199	2014	Burch *et al.*	Academic	USA	Empirical	Service based logistics organization
200	2014	Chaplin and O'Rourke	Both	UK	Empirical	Food industry
201	2014	Drohomeretski *et al.*	Academic	Brazil	Ex. Longi	Manufacturing
202	2014	Ellis *et al.*	Academic	USA	Empirical	Airline industry
203	2014	Ghane	Academic	USA	Empirical	Software/IT
204	2014	Ghosh and Maiti	Academic	India	Empirical	Foundry industry
205	2014	Gijo and Antony	Both	UK, India	Empirical	Super specialty hospital
206	2014	Haefner *et al.*	Academic	Germany	Conceptual	Electronic manufacturing industry
207	2014	Jirasukprasert *et al.*	Academic	UK	Empirical	Rubber gloves manufacturing
208	2014	Kanigolla *et al.*	Academic	USA	Expl. Cross section	Engineering education institution
209	2014	Krueger *et al.*	Academic	USA	Empirical	Manufacturing
210	2014	Lertwattanapongchai and Swierczek	Academic	Thailand	Empirical	Multinational companies
211	2014	Lighter	Academic	USA	Descriptive	Hospital
212	2014	Lin *et al.*	Both	Singapore	Empirical	Outpatient eye clinic
213	2014	Panat *et al.*	Professional	USA	Empirical	Intel Manufacturing
214	2014	Ashok Sarkar *et al.*	Both	India	Empirical	Manufacturing, service
215	2014	Shing *et al.*	Both	Malaysia	Descriptive	Manufacturing
216	2014	Siddh *et al.*	Academic	India	Descriptive	Manufacturing
217	2014	Srinivasan *et al.*	Academic	India	Empirical	Furnace manufacturing
218	2014	Srinivasan *et al.*	Both	India	Empirical	Shock absorber manufacturing
219	2014	Sumant and Patel	Academic	India	Descriptive	–
220	2014	Tenera and Pinto	Academic	Portugal	Empirical	Telecommunication company
221	2014	Thomas *et al.*	Academic	UK	Expl. Cross section	Manufacturing
222	2014	Tshibangu	Academic	USA	Empirical	Printing press

Table IV.

(*continued*)

S. no.	Year	Authors	Demography Profile of authors	Country	Methodology	Type of industries
223	2014	Van den Bos *et al.*	Both	The Netherlands	Empirical	Construction industry
224	2014	Venkataraman *et al.*	Academic	India	Empirical	Automotive manufacturing plant
225	2014	Vinodh *et al.*	Both	India, Qatar	Empirical	Rotary switches manufacturing
226	2014	Youssouf *et al.*	Academic	Romania	Empirical	Manufacturing
227	2015	Bhamu and Sangwan	Academic	India	Empirical	Ceramic industry
228	2015	Hess and Benjamin	Academic	USA	Descriptive	Oklahoma State University
229	2015	Jamal *et al.*	Academic	Malaysia	Expl. Cross section	Govt owned company
230	2015	Pacheco *et al.*	Academic	USA	Descriptive	–
231	2015	Peteros and Maleyeff	Academic	USA	Empirical	Investment sector
232	2015	Shokri and Nabhani	Academic	UK	Empirical	Business schools
233	2015	Taranikanth	Academic	India	Empirical	Technical institute
234	2015	Umude-igbru	Academic	UK	Ex. Longi	Nigerian Consulting Companies
235	2015	Vijaya Sunder	Professional	India	Descriptive	Corporate firms

Table IV.

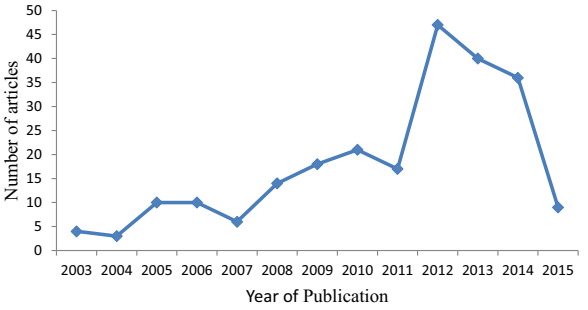

Figure 2.
Growth of LSS publications in various industries

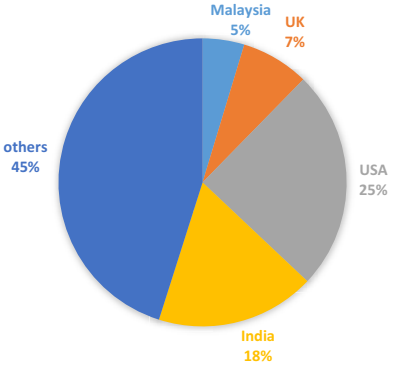

Figure 3.
Country-wise spread

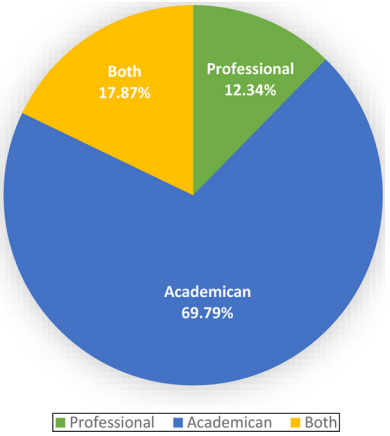

Figure 4.
Background of authors

studies, where the researchers have more control over the events being studied, which is one of the important uses of empirical data in theory building and verification. Further, they were classified as shown in the Figure 5. From the figure, it can be seen that empirical methodology is about 63.82 per cent followed by descriptive which is about 18.72 per cent. Whereas conceptual and exploratory methodology were about 5.53 and 11.9 per cent, respectively. On the whole, more importance is given to quantitative when compared with qualitative methods. Because of the lack of a conceptual method, it is difficult to understand and deploy LSS in different scenarios (Albliwi *et al.*, 2015). Further application of exploratory methodology is very less because of time constraint. So, there is a need to develop a conceptual method with a more cross-sectional approach because most of the industrial activities are related with a cross-functional team.

4.4 Lean Six Sigma spread in various industries

From Table V, it is clear that the LSS business strategy is not restricted just to the manufacturing sectors, but applicable to almost all the industries, such as financial/banking service, call center, healthcare, IT, textile, chemical industry, etc. Furterer and Elshennawy (2005) performed a case study by applying LSS tools and principles to improve the local governmental service quality. Wang *et al.* (2012) developed a continuous process improvement tool to better understand and improve a bank's competitiveness, by building a banking system which has demonstrated effective operations. Various researchers agree

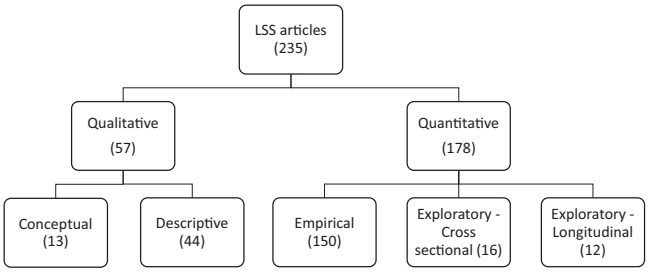

Figure 5.
A schematic tree of research methodology on LSS articles

S. no.	Author	Year	Industry sector
1	Furterer and Elshennawy	2005	Local government
2	Thompsen	2005	Military organization
3	Crino *et al.*	2007	Army
4	Andersson *et al.*	2009	Pharmaceutical industry
5	Delgado *et al.*	2010	Financial service
6	Kanakana	2010	Engineering education institution
7	Laureani and Antony	2010	Call center
8	Wang and Chen	2010	Banking services
9	Cunha *et al.*	2011	Software development for mobile phones
10	Johnstone *et al.*	2011	Drug discovery environment
11	Tua *et al.*	2011	Telecom industry
12	Arumugam *et al.*	2012	Airport security service
13	Cheng and Chang	2012	Non-profit organization
14	Cloete and Bester	2012	Veterinary laboratory
15	Furterer	2012	Acute care hospital
16	Manville *et al.*	2012	Digital document management service
17	Psychogios and Tsironis	2012	Airline industry
18	Wang *et al.*	2012	Banking sector
19	Ashok Sarkar *et al.*	2013	Insurance sector
20	Franchetti and Barnala	2013	Recycling industry
21	Karthi *et al.*	2013	Textile Mill
22	Lee *et al.*	2013	Logistics center
23	Liebtag	2013	Accounting Industry
24	Meza and Jeong	2013	Johnson Space center, NASA
25	Wong *et al.*	2013	Aircraft spare management company
26	Rizvi	2013	Laboratory experiments
27	Cournoyer	2013	Chemical process
28	Besseris	2014	Food industry
29	Lin *et al.*	2014	Outpatient eye clinic
30	Tshibangu	2014	Printing press
31	Van den Bos	2014	Construction company
32	Hess and Benjamin	2015	Oklahoma State University
33	Jamal *et al.*	2015	Government-owned company
34	Peteros and Maleyeff	2015	Investment sector
35	Shokri and Nabhani	2015	Business schools
36	Taranikanth	2015	Technical institution
37	Umude-igbru	2015	Nigerian consulting companies

Table V. Author's contribution of LSS application in non-manufacturing sectors

that the world is now in the post-modern era, in which quality of life is the guiding principle in society. As a result, services like health, education, transport, construction, financial services like banks, accounting firms and even public services have collectively come to form the foundation for citizens who avail the services of these organizations in this new post-industrial era (Suárez-Barraza *et al.*, 2012).

Overall, the spread of LSS projects in the private sector can easily be measured in monetary value, where the implementing authority follows a defined path for the success of the program. It is different with the public sector, where government organizations operate their funds under a controlled budget where profit is not the main focus; instead, each organization is liable for fulfilling the organization's mission (Meza

and Jeong, 2013). Delgado *et al.* (2010) demonstrated breakthrough results from the application of LSS in financial services in four case studies on Dutch multinational insurance companies; one particular industry of great importance, in terms of technology, regulations, customer demand and competitive actions, is the telecommunications industry (Psychogios *et al.*, 2012a). So, a growing pressure to improve efficiency and effectiveness seems to be an ongoing feature that faces the post-industrial organization, which now also finds itself in a full global race. Van den Bos *et al.* (2014) applied LSS in a construction company and found that it is an efficient technique to improve the throughput time of the projects.

Besides, Atmaca and Girenes (2011) made a sector-wise study of LSS and highlighted their tools and techniques. The frequency distribution of the LSS spread in different sectors is shown in Table VI. It is very clear that much of the LSS spread is in the manufacturing sector which is about 42.13 per cent. Among the 99 articles from manufacturing sector, 38 articles proved that following LSS in their organization helped in reducing variation and increased their throughput time in manufacturing parts like semiconducting chips, PC components, fabrics, automotive valves, display equipment (Hu *et al.*, 2008; Niu *et al.*, 2010; Atmaca and Girenes, 2011; Vinodh *et al.*, 2011; Wang and Chen, 2012). The service sector accounted for 34.89 per cent of the articles. Most of them deals with healthcare followed by information technology-enabled services (ITES) which is a good sign because reduction of process error in healthcare and ITES is the need of the hour in many countries.

On the contrary LSS spread in both agro and food industries is very less because of lack of awareness and business benefits that LSS could offer to these industries, whereas the LSS spread is about 10 per cent on infrastructure. This industry has understood the benefits of LSS and started adopting LSS in their practices to remove waste and increase their throughput time (Van den Bos *et al.*, 2014).

Industry	No. of articles	(%)
1. Manufacturing sector	99	42.13
Aerospace	6	2.55
Automobile	23	9.79
Chemical	4	1.70
Electronic components	8	3.40
Parts manufacturer like shock absorbers, ceramic, valves, etc.	38	16.17
Others	20	8.51
2. Service sector	82	34.89
Banking/Finance	16	6.81
Education institutes	4	1.70
Government organizations like space station, military, etc.	7	2.98
Healthcare	33	14.04
ITES – Information technology-enabled services	23	9.79
3. Infrastructure	10	4.26
4. Agro/Food industries	5	2.13
5. None	39	16.59
Grand total	235	100

Table VI. Frequency distribution of type of sectors covered by LSS articles

4.5 Literature review – gaps and agenda for future research

From the review, the author has found certain gaps from the LSS articles. They are as follows:

- Most organizations prefer Lean or Six Sigma or a synergy of both, i.e. LSS, to improvise their quality. But, using LSS as a tool rather a technique is not a holistic approach. In addition, there are no clear guidelines available for organizations regarding LSS deployment in different situations.
- Lack of awareness among workers and managers regarding the need and importance of LSS. It is one of the best strategies for success. But, most of the articles reviewed are yet to migrate to the LSS technique.
- Creating a learning environment for the employees to understand the various phases of LSS and training them on the appropriate tool (project charter, control charts, etc.) for each phase (DMAIC, acronym for Define, Measure, Analyze, Improve and Control).
- Need for more conceptual methodology in research is required for practitioners to easily interpret the concept and help them work efficiently in a multidisciplinary environment.
- Nowadays, it is obvious that LSS has to be integrated with the other philosophies such as supply chain, agile manufacturing, sustainability and environment-friendly techniques (Green-focused LSS).
- Presence of LSS is found in various industries for this review. But, most industries like agro, food, construction, education and pharmaceuticals require a strong LSS framework to meet the changing demand in their critical activities.
- The most important issue is that there is no generalized model for LSS implementation for most of the industries and there is no clear picture of the tool usage in various phases of LSS implementation.

5. Implications

The study contributes in the field of LSS spread in different industries using a systematic literature review. The literature review process has pointed out the efficacy of LSS spread. The study has identified LSS attributes like theme, research methodology adopted, type of industry, author profile and country of research which are crucial for researchers to understand how LSS has evolved in different industries during any given time distribution. Further, it gives an insight into the contribution of authors from both developed and developing countries and how they can use synergies for enhancing the LSS approach in different sectors. Similarly, practitioners can work with academicians to find solutions for more practical problems in industries rather than theory building. Researchers can refer to this study to learn about the LSS spread in different industries and understand what made it possible. While, practitioners can refer to this study to understand the benefits of LSS in many industries and create awareness among fellow workgroups. The study has discussed in detail the various research methodologies in the LSS field. Of the 235 articles, 178 articles are empirical in nature. This shows that the LSS approach gives more feasible solution in many industries and is widely used by both members of middle and top management. It is important for researchers and

practitioners to be aware of LSS attributes before starting the LSS journey. Hence, this paper could be used as a ready reference for both researchers and practitioners.

6. Limitations

Some papers on LSS may have been left out of this review because of the inclusion and exclusion criteria that were developed by the researchers to include pioneering journals as well as the accessibility of journals. Another limitation is the narrowing the study on LSS spread which failed in accounting the tools used and waste elimination. Apart from this, future research can be focused on studying the obstacles and critical success factors of LSS in different industries.

7. Conclusion

This paper compiles various definitions of LSS reflecting the spread, principles and scope of LSS. This paper also presents a review of 235 research papers on LSS during 2003-2015. The review focusses on LSS spread by analyzing the articles' time distribution, author profile, research methodologies and sector-wise classification. Following conclusions can be drawn from the review:

- Theory verification through descriptive and conceptual studies has been the focus of research in LSS. More research is based on empirical studies rather than exploratory cross-section studies. Most of the articles were published by academicians, with practitioners having contributed fewer articles.
- Papers from different countries like the USA, the UK, India, Malaysia, The Netherlands, etc. show that LSS research is conducted across the globe. The USA and UK are the major publishers in Western countries followed by India and Malaysia in Asia.
- Authors from developing countries like India have published articles on practical problems in a continuous span of time, showing that the LSS culture is widely spread in India.
- LSS research is mainly focused on the manufacturing sector, but LSS has also spread to other type of industries. However, the adoption of LSS in small and medium enterprises is not widespread because of the implementation cost, uncertainty and lack of a clear roadmap for deployment.
- Most of the LSS articles were focused on the empirical type of research which shows that LSS can solve complex problems because of its data-driven approach.
- The success of LSS depends largely on the organizational culture and work practices. Most of the industries have yet to adopt LSS as part of their organization's culture.
- LSS spread has found applications from manufacturing to service sectors; labor-intensive industries to technology-intensive industries; mass production to high variety and small volume production; medical healthcare to communication industry; construction industry to assembly industry; and logistics industry to defense. This show the spread of LSS in various organizations and the fact that LSS is one of the best strategies for organizational excellence is justified.

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