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A Morphological Analysis of Research Literature on Lean Six Sigma for Services

ABSTRACT

Purpose –The purpose of this paper is to review the existing literature on Lean Six Sigma (LSS) for Services, construct a Morphological Analysis (MA) framework, and identify research gaps to point to future research possibilities and priorities.

Design/Methodology/Approach –The MA framework is based on literature review of 175 papers published from 2003 to 2015, across 67 journals recognised by Scopus or ABS Academic Journal Quality Guide 2015. A three-phased methodology is used by the authors, with Phase1 featuring a five-stage systematic review protocol to identify relevant journal papers for review; Phase2 presenting a framework for classifying the reviewed papers in terms of their fundamental, methodological, chronological and sector-wise orientations, and; Phase3, constructing an MA framework on the classified papers and identifying the research gaps.

Findings – The MA framework constructed based on 6 dimensions, viz., Organizational Context of Applications, Desired Outcomes, Implementation Systems, LSS Tools and Techniques, Integration with other Management Philosophies, Evaluation Methods, involving 40 focused themes has revealed 355 distinct research gaps as opportunities for future research.

Originality/value – The MA framework of the existing literature on LSS for Services presents a unique, systematic effort to identify research opportunities. In addition, a five-stage systematic review protocol is proposed in this paper. This could be valuable to researchers and practitioners in enabling them to systematically review the literature on research subjects of interest to them.

Practical implications –This paper confirms the existence of substantial scope and points to specific topics for further research in the area of LSS for Services. The findings demonstrate the gaps in academic research on the subject. In addition, the study also helps organisational leaders and practitioners to look at LSS from a holistic perspective in the services context.

1. Introduction

Process Improvement (PI) is among the central aims of organizations, which seek to achieve quality and operational excellence (Assarlind et al., 2012). Although strongly associated with the *quality movement* of the 1980s, PI as a concept has roots in many other fields, including socio-technical systems design and the human relations movement (Bessant et al., 2001). PI programs have evolved over the years and have been associated with the adoption of lean manufacturing techniques, Total Quality Management (TQM), employee and customer satisfaction programs, customer Services excellence initiatives, and waste reduction crusade (Singh et al., 2015). While PI initiatives have been taken in both Manufacturing and Services organizations, the need for PI in Services, especially in economies dominated by the Services sector, can be justified. The service sector dominates the UK economy, contributing around 78% of GDP. More than 80% of the USA's GDP during 2010 has been contributed by Services operations (Wang and Chen, 2010). Even in emerging economies like India, the share of the Services sector is expected to reach 62% by FY 2020 (IBEF, 2015). The inherent characteristics of Services like *heterogeneity, intangibility, perishability, and inseparability* equate to greater inconsistency in managing customer experiences (Yuen et al., 2015; Ladhari, 2009) and hence make PI initiatives more convoluted. Lean and Six Sigma are regarded among the most popular management strategies for enabling PI in organisations (Albliwi, 2015). Though Lean and Six Sigma were developed independently, both these powerful PI strategies have emerged from Japanese

ways of working, adapted across the globe. Both Lean and Six Sigma have been successfully deployed in the Services sector and have been identified with some shortcomings. The hybrid LSS approach to PI has proved to overcome the shortcomings (Vijaya Sunder, 2013). This is the primary motivation of this study. Secondly, from a systems thinking perspective (Oshry, 2008), it is evident that LSS needs to be studied as a whole, and not as collection of parts (Lean and Six Sigma separately), since the whole is often other than (or, sometimes more than) the sum of the parts according to Gestalt theory (Wertheimer and Riezler, 1944) and also according to Aristotle (Corning, 2002). Hence, this study focuses on LSS as a whole. Moreover, LSS and its predecessors have been widely used in the Services sector and perceived as a subject of practitioner's interest, but there has been limited rigorous academic research (Bendell, 2006; Nonthaleerak and Hendry, 2008). Even now, we can observe that there is sufficient scope for research on various aspects concerning LSS. This has led us to systematically identify the scope for further research on this topic, within the context of the Services sector.

The paper is organised into seven sections. Following this introduction, a brief theoretical background of Lean and Six Sigma, in Services is presented in Section-2. Details about the methodology are mentioned in the Section-3, featuring about the five-stage protocol used in this study. Section-4 presents taxonomy of the reviewed literature in four sub-sections viz., fundamental classification, methodological classification, chronological classification and sector-wise classification. Section-5 presents an overview of the Morphological Analysis (MA). This section features the development of an MA framework from the six dimensions (involving 40 variables) identified from the literature, revealing 355 distinct research gaps. A discussion on the broad areas of future research is presented in Section-6, followed by concluding notes in Section-7.

2. Theoretical Background

Before performing a comprehensive literature review on LSS for Services, it is essential to understand its predecessors - Lean and Six Sigma. This section outlines a brief theoretical background about Lean and Six Sigma, highlighting their successes and shortcomings in Services sectors.

2.1 Lean for Services – successes and shortcomings: The origins of Lean thinking can be traced to the shop-floors of Toyota Motor Corporation (Shingo, 1988). Womack et al., (1990) through their book *The Machine that Changed the World* popularized the Lean concept in the Manufacturing sector. The practices of Lean slowly penetrated into American firms in the 1970s and then across the globe swiftly. Lean principles involved the identification of customer value, managing the value stream, developing the capability to flow, the use of *pull* and the pursuit of perfection in the production system (Womack and Jones, 1996). Lean tools such as value stream mapping, 5S and waste analysis have been relatively easily transferred from the manufacturing supply to retail supply contexts due to the common focus on product flows (Bicheno, 2004). Though originated from the Manufacturing sector, Lean's significant potential for the Services industry has also been realized. Lean is more frequently applied outside the Manufacturing sector, especially in Services (Bowen and Yongdahl, 1998). As a successful PI strategy; Lean has demonstrably helped organizations achieve on-time delivery of the right quality and quantity of Services to satisfy customers. There are several recent success-stories of Lean in Services published in various journals since 2010, a few of which are presented in Table 1.

Table 1: Success of Lean in Services

Alongside the success, Lean has shortcomings on several counts and has encountered criticism from researchers. According to Spear (2004), many organisations wrongly

perceived Lean as a set of tools and practices rather than as a PI philosophy. This misconception led to confusion in many organisations in their attempts to motivate employees to participate in Lean programs. Critics argued that Lean is not the only effective solution for customer satisfaction and Lean by itself is not all perfect; Toyota's performance in Europe in the recent past has often been lacking. According to Bhasin (2015), "...even Toyota in Japan, failed to produce in several circumstances, cars to actual customer order". Maiké et al., (2009) found that the approach to implement Lean produces a cascading effect of problems, including lack of senior management commitment and team autonomy. It could be argued that senior management commitment is essential for any and all PI initiatives, and not just for Lean. However, the bottom-up approach of Lean makes it more challenging to gain organisational leaders' commitment towards it. Parker and Slaughter (1994) noticed through various Lean implementations, that top management avoids accountability when problems arise, letting it filter downwards onto the lower levels of hierarchy. This view of Lean, contradicts the fundamental PI principle of spreading a quality mind-set within organisations. However, a few authors who have contributed to Lean Literature have highlighted the top-down approach, Hoshin Kanri (policy deployment) which is a method for ensuring that the strategic goals of a company drive top-down progress and action by focusing on eliminating the waste that comes from inconsistent direction and poor communication (Kondo, 1998; Witcher and Butterworth, 1999). A few other Lean thinkers supplemented this literature with 'Catchball', which refers to the bi-directional top-down, bottom-up process through which objectives, plans, and metrics are spread among levels and departments (Nicholas, 2016; Kunonga et al., 2010). Another drawback of Lean is not being a data driven approach unlike other PI programs including Six Sigma. The use of a wide variety of management practices in Lean implementation validates the requirement for various generic performance indicators and there is a need to measure them effectively.

Bhamu and Sangwan (2014) claimed that there was no evidence of any such measurement system in Lean literature. There are a few arguments that some of the Lean principles like *Pull* do not add any value within the Services industry. This is because Pull is inherent in the nature of Services, and Lean has nothing new to add here (Arfmann and Federico, 2014).

2.2 Six Sigma for Services – successes and shortcomings: The Six Sigma movement, which originated from Motorola, has spread to other organisations determined to deploy PI. Many Fortune 500 firms adopted Six Sigma as a practice (Nakhai and Neves, 2009). According to Barney (2002), Six Sigma integrates business-level performance, process measures, and project metrics into a systematic process so that leaders can manage the organisation quantitatively and transform the business strategy into calculated tasks. Till the 1990s, Six Sigma was understood solely as a statistical term used for restricting process defects to 3.4 per million opportunities. During the last two decades, it has evolved from being a statistical problem-solving technique to become a management strategy and ultimately a refined PI philosophy. Six Sigma not only focuses on reducing process variations and defects, but also encourages creating a process thinking mind-set in organisations (Vijaya Sunder et al., 2015). Six Sigma improvement projects follow a structured problem solving approach which takes its roots from the Plan-Do-Check-Act (PDCA) cycle (Schroeder et al., 2008). It suggests two project management approaches, namely, Define-Measure-Analyse-Improve-Control (DMAIC) and Define-Measure-Analyse-Design-Verify (DMADV), for eliminating the root causes of problems. According to Michael Hammer, at least 25% of the Fortune 200 companies claim to have a serious Six Sigma program (Thawani, 2004). Six Sigma has been embraced by many big Services firms such as J P Morgan, American Express, Lloyds TSB, Egg, Citi Bank, Zurich Financial services, etc. (Antony, 2006). Though originated from Manufacturing, there is evidence in the literature that Six Sigma has been adopted and

applied outside the Manufacturing sector too. There are several recent success-stories of Six Sigma in the Services sector published in various journals since 2010, a few of which are presented in Table2.

Table 2: Success of Six Sigma in Services

Like Lean methodology, Six Sigma also encountered criticism due to its limitations. Though the practitioner literature provides considerable evidence of substantial cost reduction and other benefits from Six Sigma, some still question whether these benefits sufficiently exceed the costs of adoption (Swink and Jacobs, 2012). Stories from companies like General Electric and 3M indicate that organisational leaders believe Six Sigma practices may constrict innovation to drive growth (Hindo, 2007). Many Six Sigma programs failed due to wrong selection of projects. Not all projects qualify to be run in Six Sigma methodology (Vijaya Sunder, 2013). According to Adams (2003), “doing Six Sigma training before project identification is the classic – getting the cart before the horse”. Further to this, a few critics perceived that the *Define* and *Control* phases were areas of weakness in the DMAIC methodology and that unconventional execution of these phases is suggested (Nonthaleerak et al., 2008). Antony (2006) highlights more limitations of Six Sigma like the challenge of having quality data in processes where no data is available. He also claims that prioritisation of projects in many Services companies is still based on pure subjective judgement. Hoerl (2001) argues that there is no standardised procedure for accrediting Six Sigma programs. This entertains organisations to claim they are following Six Sigma which may not be true in many cases. Another important shortcoming of Six Sigma is the amount of investment made by firms on niche skilled Six Sigma belts for deployment. Yet another challenge of implementing Six Sigma is the usage of statistical techniques during projects, which

management feels difficult to comprehend (Vijaya Sunder, 2014). Another shortcoming is that the relationship between Six Sigma and organisational culture has not been explored in the literature (Antony, 2004). Moreover, many organisations still perceive Six Sigma as a pure statistical toolkit rather than as a management strategy, and there is no significant work found in literature to overcome this misconception. There is very little room for clarifying the confusion in the literature as to what constitutes Six Sigma theory and how does it integrate with other PI strategies (Gamal, 2010).

Our aim is not to undermine the effectiveness of Lean or Six Sigma as PI methodologies, but from the above discussion it is evident that both Lean and Six Sigma have proven successes as well as have drawbacks. Research indicates that integrating Lean with Six Sigma could bring in more synergies to organisational processes, especially in the Services sector. Hines et al., (2004) have indicated that it is possible to integrate Lean with other approaches, without contradicting its objective of providing customers with value. George (2002), in his book '*Lean Six Sigma: Combining Six Sigma Quality with Lean Speed*' introduced the term 'Lean Six Sigma' (LSS). Though it is possible that the term *Lean Six Sigma* has been used even before, there is no concrete evidence found in the literature till 2002. A year later, another book – '*Lean six sigma for Services*' justified the applicability of LSS in Services (George, 2003). The claim that Lean and Six Sigma have a complementary relationship is widely accepted today in the corporate world. LSS has been acknowledged by more than 70 per cent of Fortune 500 companies across various Services (Chassin, 2008; Antony, 2015).

3. Methodology

LSS for Services, as an approach to PI, is yet to fully mature into a specific area of academic research (Bendell, 2006). Through the proposed MA framework, this paper points out that

even now there is sufficient scope for a comprehensive study to explore new possibilities and priorities for research on this topic. Here, we perform a systematic literature review of the hybrid LSS methodology (not Lean or Six Sigma in isolation) in the Services sector.

According to Gamal (2010), academicians and practitioners often make use of journals to obtain and publish the highest level of research findings. In this paper, therefore, we included studies published in journals with outcomes adding to the theoretical body of knowledge and applications. An online literature search was performed for publications from 2003 to 2015. This revealed a comprehensive set of papers on LSS. However, it is possible that a few papers that were unintentionally not investigated as a part of this study may exist. Tranfield et al., (2003) stated that *systematic* review has become a fundamental scientific activity and hence essential for the literature. For this purpose, we have used a five-stage protocol:

1. A search was conducted in the abstract field of the following databases – Emerald, Taylor and Francis, Springer, IEEE Xplore, Mendeley, Science Direct, Wiley, Elsevier, Sage, INFORMS, Inderscience, ASQ and HBR, with the search terms: “Lean Six Sigma”, “LSS” “Lean Six Sigma for Services” for the period from 2003 to 2015. This resulted in a total of 803 relevant articles. Various related combinations of keywords only led to subsets of these 803 articles.
2. The duplicate results were eliminated using the Mendeley desktop software. This led to a reduced number of 653 articles.
3. A large number of articles dealing exclusively with the Manufacturing sector were excluded. Reading through the abstracts, 416 articles relevant to *Services* were identified.
4. From among them, 136 articles published in journals listed in *Scopus* or *ABS Academic Journal Quality Guide 2015* were identified.
5. According to Zorzini et al., (2015), a mechanical search of review articles should be supplemented by an organic search to obtain comprehensive search output. Hence, an

organic search was performed to identify other relevant papers that were cited in these 136 articles. This search brought the final total to 175 articles, spread across 67 journals.

Table 3: Publications across journals

A Microsoft Excel database was formed for classifying these 175 articles into different headings for the purpose of analysing the trends in the body of knowledge. *Table 3* shows an increasing interest in research publications pertaining to LSS in Services. Full paper analysis was performed and a four-fold classification framework was developed (*Figure 1*). Firstly, a *fundamental* classification was performed on the basic details of the reviewed journal papers. Details like title, author, year, journal, Services sector details and country of the author were considered for this purpose. The second level of classification (*methodological*) was based on the *research method details* given in the papers. This included research type, methodology, data used, research context and research topic. Thirdly, *chronological* classification was performed to understand the evolution of LSS in Services. Then, a *sector-level* classification was performed based on the research contributions across different Services sectors. The classification framework helped to identify different themes available in the literature on LSS for Services from the reviewed papers.

Here, MA has been used to identify research gaps to enable future research. The themes identified through the above four classifications were used as dimensions in the MA framework. A brief description about MA and the motivation behind its use is presented in Section 4.

Figure 1: Methodology

4. Overview of the Literature

The four orientations in the research literature, based on which the classification has been done are elaborated below.

4.1 Fundamental classification: More than 100 authors have contributed to the body of knowledge through 175 papers in 67 journals. Significant contributors include (and not limited to) Antony J, Douglas A, Dahlgard-Park SM, Bendell T, Sarkar A, Chiarini A, Ghosh S, Kumar M, and Laureani A. The classification framework reveals that the contributors are from 26 different countries. The contributions from USA, UK, India, Sweden, Netherlands, Italy and Australia constitute 80% of the publications. This classification also reveals that 6 out of 67 journals contributed to 50% of the overall publications on the subject. They are *International Journal of Lean Six Sigma* (34 papers), *Total Quality Management and Business Excellence* (16), *International Journal of Quality and Reliability Management* (14), *The TQM Journal* (14), *International Journal of Productivity and Performance Management* (11) and *Quality Progress* (5).

4.2 Methodological Classification: Table-4 presents an overview of the research methods, sources of data, proportion of papers using specific methodologies and sample papers. In all, 30 theoretical papers and 145 empirical studies appeared. The theoretical publications included conceptual or desk analysis by various researchers. The empirical papers limited to descriptive and experimental studies were further classified based on data collection methods. 93 papers appeared to have used primary data collection methods. The primary data category consisted of 66 papers dominated by case studies and action research. This category also included questionnaire methods, interviews, viewpoints and experiment data sources, used in the remaining 27 papers. Thus, we can observe that there is a need for more empirical research that considers non case-study methods. There were only 24 papers that leveraged

secondary data from existing literature and public data sources. The use of multiple primary research methods (mixed methods) were identified in 28 of the reviewed papers.

Table 4: Methodological classification of reviewed papers

4.3 Chronological Classification: Total quality management (TQM) was recognised as the most widespread quality management approach from the beginning of the 1990s. However, during the first decade of the new millennium, emerging PI methodologies such as Lean and Six Sigma seem to have overtaken (Elshennawy, 2004; Chiarini, 2011). The proven success of Lean and Six Sigma helped LSS to be recognised by practitioners and academicians as a powerful PI methodology for customer satisfaction. Hence, researchers have tacitly accepted LSS as a PI methodology. From the early 2000s, the evolution of LSS has been significant. Though LSS for Services was introduced as a concept in 2003, there were no specific papers from the reviewed literature on the topic till 2004.

2004 to 2007: During this period, new quality techniques for PI were adopted. These were beyond the earlier quality philosophies like TQM. The papers focussed on the *modern quality movement* and called Lean and Six Sigma as structured PI techniques in the new age of high technology (Bendell, 2005; Bullas, 2007; Lee et al., 2005). The need for upgrading the skills and knowledge of PI professionals through LSS toolkits for effective quality management was identified (Elshennawy, 2004; Maguad, 2006). Though researchers appreciated Lean and Six Sigma as distinct PI methodologies, they also noticed a linkage between the two. Strengths and weaknesses of Lean and Six Sigma were assessed to identify common and distinct features of the two methodologies leading to several exploratory and descriptive studies for integration (Arnheiter, 2005; Snee et al., 2007; Caldwell, 2006a; Andersson, 2006; Koning et

al., 2006). With this, the focus shifted towards understanding LSS as a single hybrid methodology rather than as being made of individual PI programs in isolation. Sharma (2004) described the integrated LSS methodology as a driver for strategic improvement. Several case-studies and action research papers highlighted the integrated LSS approach for PI (Less, 2005; Marti, 2005; Aldarrab, 2006). The practical implications tinted the importance of data measurement, leadership, organisation culture, innovation, customer focus, fact-based approach, agility, focus on results and project management in the context of successful LSS implementation for Services (Caldwell, 2006b; Dahlgard et al., 2006). However the integrated LSS methodology received some criticism. Bendell (2006) claimed that LSS could dilute the effect of Lean and Six Sigma due to the lack of specific LSS training programs. Kumar et al., (2006) highlighted the lack of a standard framework for LSS implementation.

2008 to 2011: This period witnessed a synergy of LSS implementation in Services. It was reported that the overall popularity of LSS had been growing in Services (Guarraia et al., 2008), specifically in healthcare Services (Zieger, 2009). Researchers confirmed that LSS is not merely an integration of Lean and Six Sigma, rather a management strategy which can deliver significant benefits much higher than Lean or Six Sigma individually (Antony, 2011; Barnes, 2010; Snee, 2010; Goh, 2011; Shah, 2008; Salah, 2010). Elg el at., (2011) demonstrated that LSS practitioners in contemporary organisations have the responsibility to lead quality at the strategic level. Laureani and Antony (2011) claimed that LSS certification practice is important to determine the competency level of the practitioners. Other authors identified LSS certification standards to be used in organisations, drawing on the best practices from major companies. Researchers felt a need for structured application of LSS and hence several *frameworks* emerged (Jeyaraman and Teo, 2010; Montgomery, 2010; Kheradia, 2011; Karthi, 2011). Publications also identified several *critical success factors*

(CSFs) which could lead to the success of LSS (Naslund, 2008; Jenica et al., 2010; Kumar et al., 2009; Clegg et al., 2010). A few authors have discussed the *implementation issues* of LSS. Sarkar et al., (2011) argued that all processes cannot be taken up simultaneously for PI, and hence project selection becomes a key implementation issue. They identified an empirical roadmap for this purpose. Koning et al., (2010) identified seven standard LSS project definition templates which have explicitly stated goals and a solid business rationale for project management. Hoerl and Gardner (2010) claimed that LSS promoted creativity and innovation. They acknowledged that LSS was the best approach for addressing major “solution unknown” problems. From the reviewed papers, 23 case-studies were identified between 2008 and 2011, showcasing the successful application of LSS in various Services sectors (discussed in sector-wise classification). As the success of LSS caught fire across Services, there have been questions from critics about the *assessment methods*. Black (2009) argued that LSS implementations should have a realistic evaluation by which assessing and considering the individual characteristics of an organization's social environment could lead to successful PI. An early assessment model for LSS was suggested by Corbett (2011) based on six attributes –leadership, strategic planning, customer and market focus, measurement, analysis and knowledge management, employee focus, and process management.

2012 to 2015: Dahlgard et al., (2013) highlighted the importance of LSS in the context of quality management and claimed that the focus had shifted from being initially on TQM to tools and techniques, and then to core values needed for building a quality and business excellence culture. A few authors argued LSS a management strategy that Services firms often built to create a specific quality profile, which they retained over time. In addition to the debate surrounding LSS as a management strategy, the body of literature on dynamic capabilities is also of particular interest to researchers (Bititci et. al, 2011). McAdam et al.,

(2014) identified LSS as a best practise as a part of their research on performance measurement models, since it helped improve operational measures for greater process capabilities. Various studies highlighted the implementation of LSS in new Services like Services supply chain, higher education, hospitality, etc., Several other authors noticed LSS as a differentiating factor when integrated with other quality philosophies in the Services context for process improvements, due to its success and popularity (Goldis, 2013, Kanigolla et al., 2014). According to Bhamu (2014), a structured cross-fertilization of LSS methodology can be used in a wide range of projects to tackle specific problems. Adding to the previous researchers, several other CSFs were identified which included readiness factors and critical failure factors (McLean et al., 2014; Antony, 2014; Näslund, 2013; Albliwi et al., 2014). Maleyeff et al., (2012) argued that the traditional LSS methodology needs to be customised based on the nature of services for changing environments. With sector-specific customisation in LSS methodology, several new frameworks emerged (Karthi et al., 2014; Nicoletti, 2013; Madu, 2014). Contributions on customising LSS toolkits were also witnessed during this period (Sahay, 2015; Antony et al., 2012). Global studies about the implementation of LSS found it fit for Services in human resources management (Bamber et al., 2014; Sahay, 2015). Challenges faced in implementing LSS in pure Services environments were also identified (Vijaya Sunder, 2013; Antony et al., 2012b; Antony, 2015). A total of 37 case studies and action research papers were published on various Services in organisations.

Figure2: Summary of Chronological Classification

4.4 Sector-wise classification: The review found that 9% publications (16 papers) appeared from Services in the Manufacturing sector and 43% (76 papers) of the publications were found to be generic across the Services sector. Examples of Services in Manufacturing

include hiring processes, logistics, packaging of goods, safety, administrative processes, etc. These publications included LSS concepts, frameworks, theoretical contributions and exploratory and descriptive studies applicable across all services. The remaining 83 papers were sector-specific and spread across the Services sector (see Table 5). The highest contributions appeared in Healthcare, followed by Education. 6 out of 7 papers presented case studies on Banking, Financial Services and Insurance. A sample of such papers across the Services sector is presented in Table 6. The table also illustrates the benefits of LSS in Services and provides evidence of application of LSS in Services. Reduction in cost, risk, defects and process-time, and improvement in customer satisfaction, employee satisfaction, process-quality, cultural transformation and business value were LSS' proven benefits stated in these papers. The recent publications of LSS in non-profit organisations clarify that it not only helps organisations deliver bottom-line benefits, but also helps transform organisational culture for business value and excellence. Consolidating this discussion with the case studies published in Education, it is evident that LSS not only contributes to process improvement and cultural transformation in business enterprises but also in social enterprises where defining the 'customer' is unclear (Holmes et al, 2005; Antony, 2015).

Table 5: Sector-wise classification of reviewed papers

Table 6: Application of Lean Six Sigma across Services sectors

5. Morphological Analysis (MA)

MA is a qualitative technique widely used in social sciences, for structuring and investigating the total set of relationships contained in multi-dimensional, non-quantifiable contexts (Ritchey, 2011). It involves examining the entire set of combinations of possible values of various dimensions of a concept (Zwicky, 1969) to identify the gaps. It provides a

method to identify and investigate elements of a system (or a concept) in its existing form and to explore possible configurations (or opportunities) which the system could have (Majer, 2007). Xin et al., (2010) applied MA for identifying new technology opportunities for practitioners and policy makers. Sudhindra et al., (2014) used MA to build a knowledge classification model in supply chain networks. According to Majaro (1988), it is an ideal technique for generating new ideas in respect of exploratory and opportunity seeking requirements as the need to define a problem in detail is less stringent in this approach. Muller-Merbach (1976) pointed out that general morphology is especially a suitable tool for operational research, not simply dealing with of pre-defined problems, but to be proactive in problem formulation processes for identifying gaps for future research. Ritchey (2011) describes that identifying and defining the most important dimensions of the concept under investigation form the primary steps in MA. Each of these dimensions is then given a range of relevant values or conditions. Together, these make up the variables of the problem to be structured.

In this paper, the key themes of LSS in the Services sector have been identified from the reviewed literature (discussed in Section-3). Then, based on the judgement of the authors these themes have been grouped into six broad dimensions of the MA framework. It is important to note that the development of an MA framework demands judgement, and it is quite likely that different authors may develop different MA frameworks, made of corresponding dimensions, even of the same concept they seek to represent. However the total or aggregation of all the contents of all such MA frameworks will be, or can be made, the same through intellectual discussions, while the form of representations would be different. This indicates the objectivity of the approach and one of the strengths of MA (Zwicky, 1969). The approach requires and involves a combination of objectivity and judgement as prevailing even in other widely used abstraction-representation approaches such

as Fishbone Diagrams, Quality Function Deployment, Failure-Modes Effects and Criticality Analysis, Mind Maps, Entity Relationship Diagrams, Rich Pictures, etc. The development of an MA framework from research literature could, in fact, actually use the constructs or dimensions specified by the respective authors in their papers. For example, the Dimension 1, elaborated upon later here, is based on Porter's depiction of organizational value chains (Porter, 2011). The MA method is very useful for 'structured or systematic creativity'. Hence, we have applied MA on the body of knowledge from the reviewed literature to identify the research gaps (opportunities for future research) in the area of LSS for Services. For this purpose, an MA framework is developed (Table 7) with six dimensions identified from the literature. The six dimensions comprising 40 variables are discussed below.

5.1. Dimension 1: Organizational Context of Application

Porter (2011), in his book *Competitive Advantage* described a chain of activities common to all businesses, and divided them into five primary and four support activities. Later, many researchers endorsed this classification of the organisational value chain for further studies. In this paper, these activities are used to analyse the application of LSS presented in the reviewed literature in an organisational context. Hence, the variables defined under this dimension are as per Porter's classification of an organisational value-chain.

Primary activities:

- VAR-1 *Inbound Logistics*: involves relationships with suppliers and include all the activities required to receive, store, and disseminate inputs
- VAR-2 *Operations*: are all the activities required to transform inputs into outputs (in the context of Services)
- VAR-3 *Outbound Logistics*: includes all the activities required to collect, store, and distribute the output

VAR-4 *Marketing and Sales*: activities inform buyers about products and services, induce buyers to purchase them, and facilitate their purchase

VAR-5 *Post Sale Services*: includes all the activities required to keep the product or services working effectively for the buyer after it is sold and delivered

Support activities:

VAR-6 *Procurement*: the acquisition of inputs, or resources, for the firm

VAR-7 *Human Resource Management*: consists of all activities involved in recruiting, hiring, training, developing, compensating and laying off personnel

VAR-8 *Technology*: pertains to the equipment, hardware, software, procedures and technical knowledge brought to bear in the firm's transformation of inputs into outputs

VAR-9 *Infrastructure*: serves the company's needs and ties its various parts together, it consists of functions or departments such as accounting, legal, finance, planning, public affairs, government relations, quality assurance and general management.

5.2. Dimension2: Desired Outcomes

This dimension elaborates the desired outcomes through the application of LSS in Services. From the literature, eight short-term/transactional outcomes and six long-term/strategic outcomes have been identified. These are basically the key tangible and intangible metrics which LSS could potentially improve or enable in Services environments.

Short term/transactional tangible outcomes:

VAR-10 *Cycle time and Cost reduction*

VAR-11 *Increase in revenue*

VAR-12 *Risk Management*

VAR-13 *Quality, efficiency and productivity improvement*

VAR-14 *Customer or Employee Satisfaction*

VAR-15 *Rework and error reduction*

Short term/transactional intangible outcomes:

VAR-16 *Enabler for effective decision making environment*

VAR-17 *Enabler for incremental innovation and continuous improvement mind-set*

Long term/strategic tangible outcomes:

VAR-18 *Improved Competitiveness/Market share*

VAR-19 *Enabler for Breakthrough and disruptive innovation*

VAR-20 *Knowledge Management*

Long-term/strategic intangible outcomes:

VAR-21 *Learning capability*: capability of an organisation to learn from its environment

VAR-22 *Business Excellence capability*: capability of an organisation to excel what has been learnt

VAR-23 *Dynamic capability*: capability of an organisation to change quickly and create a competitive edge which is difficult for others to imitate

5.3. Dimension3: Implementation Systems

This dimension maps the substantive approaches, types of resources used in implementation and various implementation issues discussed in the reviewed papers.

Substantive approaches:

VAR-24 *Six Sigma followed by Lean*

VAR-25 *Lean Six Sigma as a hybrid methodology*

VAR-26 *Lean and Six Sigma in parallel*

Resources for implementation:

VAR-27 *Operational Human Resources*

VAR-28 *Financial*

VAR-29 *Leadership Human Resources*

Implementation issues:

VAR-30 *Readiness Factors*

VAR-31 *Challenges*

VAR-32 *Success/Failure Factors*

5.4. Dimension4: LSS Tools and Techniques

This dimension maps the LSS tools which are predominantly preferred for usage/application identified, from the reviewed papers.

VAR-33 *Graphical/non-statistical tools*

VAR-34 *Statistical tools*

5.5. Dimension5: Integration with Other Philosophies

This dimension elaborates the application of LSS as an integrative model with other philosophies relevant to Services.

VAR-35 *Quality Management philosophies and other organisational practices*

VAR-36 *Systems thinking concepts*

VAR-37 *Innovation practices*

5.6. Dimension6: Evaluation Methods

The reviewed papers reveal that there are different types of evaluation methods, grouped below, adapted in organisational contexts for assessing the success of LSS:

VAR-38 *Milestone-based*: Success of LSS evaluated based on %deployment across organisation

VAR-39 *Function-based*: Evaluation of LSS implementation based on functional deployment

VAR-40 *Project-based*: Evaluation of LSS implementation based on project by project deployment

From Table7, it is evident that literature reviewed for this paper enabled mapping 9 variables under the organisational context of application, 14 variables under the desired outcomes, 9 variables under the implementation systems, 2 variables under tools and techniques, 3 variables under the integration with other philosophies, and 3 variables under the evaluation methods. This leads to 20412 ($9 \times 14 \times 9 \times 2 \times 3 \times 3$) combinatorial configurations across the six dimensions. As a next step in the analysis-synthesis process, combinatorial relationships between the variables associated within a dimension were removed to eliminate the internal combinations. For example, the inbound logistics-outbound logistics pair and the graphical tools-statistical tools pair separately represent pairs of variables under the same dimension, and do not yield meaningful combinations for further research. This process results in the refined cross-consistency-matrix showed in Figure3, where all the dimensional values in the MA framework are compared pair-wise with one another. During this process, there was no reference to direction or causality, but only mutual consistency between the paired variables was analysed. This resulted in 355 research gaps, which could be considered as possible opportunities for future research. However, researchers should apply appropriate judgement for direction and causality, before selecting a research gap for focussed research. The respective pairs of factors which reveal research gaps should be examined; and then a

selection judgment has to be made based on whether and to what extent the pairs can coexist to represent a meaningful relationship deserving focussed research.

Table 7: Morphological Analysis Framework

6. Discussion: Broad areas for future research

The novelty of this work is to point to both academicians and practitioners, focussed directions on research opportunities and questions to ponder on the subject 'LSS for services', for future research/study. A few of the broad areas are highlighted below:

- Application and comparison of LSS methodology in various distinct service sub-sectors, viz., LSS in Healthcare, LSS in Education, LSS in Banking and Financial services, etc.
- Customisation in models of LSS methodology deployment in organisational contexts, viz., customisation of LSS deployment in inbound logistics, outbound logistics, post-sale services, etc.
- To validate the hypothesis that LSS is an enabler of incremental innovation and continuous improvement mindsets in service organisations
- Validation of various tangible and intangible outcomes of LSS (defined in Section 4) in each of the services sub-sectors
- Impact of LSS deployment on competitiveness and market share in services (specific to each services sub-sector)
- To validate the hypothesis that LSS is an enabler for breakthrough and disruptive innovation in service organisations (specific to each services sub-sector)
- Synergies of LSS and knowledge management and the impacts, specific to each services sub-sector

- To validate if LSS deployment in services firms could contribute to customer as well as employee satisfaction. If so, what are the attributes, influencing factors and measures of success?
- ‘Impact of’ and ‘impact on’ human resources due to various tangible outcomes of LSS deployment in services
- Utilisation of financial resources for deploying LSS across primary and support processes in services, and its impact on the organisation
- Is LSS an enabler of learning capability in service firms?
- Can LSS be a dynamic capability in various service sectors? (specific to each services sector)
- Customisation of LSS toolkit for services sector (applicability, ease of use, preferred usage at various primary and support functions in each of the service sectors defined)
- Synergies of LSS and other quality management practices in services (Example: LSS and ISO, LSS and Balance Scorecard etc., for each of the services sectors)
- Integration of LSS with system thinking concepts and innovation practices (specific to each service sector)
- How to evaluate the success of LSS deployment in services? (conceptual models, preferred usage and validation for each service sector)

Figure 3: Cross-Consistency Matrix from reviewed papers

A deeper look at the cross consistency matrix (Figure-3) helps in identifying the gaps in the reviewed literature across the above mentioned broad areas ‘crossing’ through the various dimensions. The resultant 355 research gaps (not listed here explicitly; but, see Figure 3) identified using the MA framework reveal opportunities for future research in the areas of inbound logistics, procurement, marketing and sales from the LSS application perspective in the service context. There is scope for further action research or case studies

to validate LSS applications. From the perspective of desired outcomes, significant evidence of research exists in cost reduction, quality improvement, and customer and employee satisfaction. However, research is required to validate increase in revenue and risk management effectiveness as LSS outcomes.

Though there are papers on LSS enabling Business Excellence Capability, future research should focus on LSS for creating Dynamic Capability in organisations. According to Teece et al., (1997) Dynamic Capability refers to a firm's ability to integrate, build, and reconfigure internal and external competencies to address rapidly changing environments. Some authors have pointed out that LSS catalyses firms' learning capabilities to adapt to rapidly changing environments; this needs sound validation.

All the papers that highlighted implementation issues, viz., readiness factors, challenges and critical success/failure factors, concerning LSS in Services are generic and not specific to the Services sub-sectors. The large diversity of services calls for focused research on implementation issues specific to each sub-sector and business to derive the respective unique and distinctive insights. Though a few researchers have attempted to assess and evaluate LSS based on milestone, function and project-based methods, there is no evidence of any standard of evaluation with defined criteria for measuring the success of LSS in Services organisations. The evaluation of LSS implementation, from a systems perspective also demands a considerable amount of research. Evaluating the impact of LSS on competitiveness and market share in the Services sector presents another major research opportunity.

Several organisational and environmental factors need to be examined using a systems approach while studying LSS implementation in Services. Though there is evidence in literature of integrating LSS with other quality and organisational philosophies like ISO, Balanced-score-card and supply-chain concepts, there are large research gaps in

understanding LSS from a systems thinking perspective. These include building synergies between LSS and innovation practices for deriving organisational benefits including breakthrough and disruptive innovations.

From Figure-3, it is evident that the identification of critical success factors and deployment models of LSS in Healthcare need further research. In the Education sector, the use of LSS as a decision making platform and innovation driver, and assessment methods provide research opportunities. Much research is needed in Banking, Telecom, Food and Beverages, Non-profit and Government sectors constituting a large chunk of Services. Though significant LSS research contributions were found in Healthcare Services, there are still gaps existing in this area.

7. Conclusion

LSS has emerged as an essential part of PI in services by providing several valuable outcomes. The systematic literature review and the MA framework presented here are meant to serve as a resource for researchers seeking to understand LSS theory and practice, and its evolution leading to recent trends of its integration with other philosophies. The MA framework has enabled identification of 355 unique research gaps, and should help researchers' efforts to advance the theory and practice of LSS in Services.

From a systems thinking perspective, LSS is not merely a combination of Lean and Six Sigma, but a synergetic hybrid approach for effecting transformational change in organisations. Alongside improving customer and employee satisfaction, LSS also strives to reduce costs and manage risk in Services firms. As a management strategy, LSS helps top management in decision making, promoting innovation, and enabling organisational dynamic capabilities. This paper confirms the existence of substantial scope and points to specific topics for further research in the area of LSS for Services. The findings demonstrate the gaps

in academic research on the subject. In addition, the study should enable organisational leaders and practitioners to understand LSS from a holistic perspective in the services context.

REFERENCES:

1. Achanga, P., Shehab, S., Roy, R., and Nelder, G. (2006). Critical success factors for lean implementation within SMEs. *Journal of Manufacturing Technology Management*, 17(4), 460–471
2. Adams, C.W. (2003), *Six Sigma Deployment*, Elsevier Science, New York, NY.
3. Albliwi, S., Antony, J., Abdul Halim Lim, S. and van der Wiele, T. (2014), "Critical failure factors of Lean Six Sigma: a systematic literature review", *International Journal of Quality and Reliability Management*, Vol. 31 No.9, pp.1012 - 1030
4. Albliwi, Saja Ahmed, Jiju Antony, and Sarina Abdul halim Lim. (2015) "A systematic review of Lean Six Sigma for the manufacturing industry." *Business Process Management Journal* 21.3
5. Aldarrab, A. (2006), "Application of Lean Six Sigma for patients presenting with ST-elevation myocardial infarction: the Hamilton Health Sciences experience.", *Healthcare quarterly Toronto*, Vol.9 No.1, pp. 56-61
6. Aleem, S. (2013), "Translating 10 lessons from lean six sigma project in paper-based training site to electronic health record-based primary care practice: challenges and opportunities.", *Quality management in health care*, Vol. 22 No. 3, pp. 224–35.
7. Al-Hakim, L. and Gong, X. Y., 2012. On the day of surgery: how long does preventable disruption prolong the patient journey?. *International Journal of Health Care Quality Assurance*, 25(4), pp. 322-342.
8. Anand, G., Ward, P. T., and Tatikonda, M. V. (2010). Role of explicit and tacit knowledge in Six Sigma projects: An empirical examination of differential project success. *Journal of Operations Management*, 28(4), 303-315.
9. Andersson, R., Eriksson, H., and Torstensson, H. (2006). Similarities and differences between TQM, six sigma and lean. *The TQM magazine*, 18(3), 282-296.
10. Antony, J (2015), "Challenges in the deployment of LSS in the higher education sector", *International Journal of Productivity and Performance Management*, Vol. 64 Iss 6 pp. 893 – 899
11. Antony, J. (2004), "Some pros and cons of six sigma: an academic perspective", *The TQM Magazine*, Vol. 16 No. 4, pp. 303-6.
12. Antony, J. (2011), "Six Sigma vs Lean", *International Journal of Productivity and Performance Management*, Vol. 60 No.2, pp.185-190
13. Antony, J. (2014a), "Readiness factors for the Lean Six Sigma journey in the higher education sector", *International Journal of Productivity and Performance Management*, Vol. 63 No. 2, pp.257 - 264

14. Antony, J., Bhuller, A.S., Kumar, M., Mendibil, K. and Montgomery, D.C. (2012a)," Application of Six Sigma DMAIC methodology in a transactional environment", *International Journal of Quality and Reliability Management*, Vol. 29 No.1, pp.31 - 53
15. Antony, J., Krishan, N., Cullen, D. and Kumar, M. (2012b),"Lean Six Sigma for higher education institutions-HEIs", *International Journal of Productivity and Performance Management*, Vol. 61 No.8, pp.940 - 948
16. Antony, J., Kumar, M., and Rae Cho, B. (2007). Six sigma in Services organisations: Benefits, challenges and difficulties, common myths, empirical observations and success factors. *International journal of quality and reliability management*, 24(3), 294-311.
17. Antony, J., Setijono, D. and Dahlgaard, J.J. (2014),"Lean Six Sigma and Innovation – an exploratory study among UK organisations", *Total Quality Management and Business Excellence*, DOI:10.1080/14783363.2014.959255
18. Antony, J.,(2006) "Six sigma for Services processes." *Business Process Management Journal* 12.2 : 234-248.
19. Arfmann, David, and G. Federico. "The Value of Lean in the Services Sector: A Critique of Theory and Practice." *International Journal of Business and Social Science* 5.2 (2014).
20. Arnheiter, E.D. and Maleyeff, J. (2005),"The integration of lean management and Six Sigma", *The TQM Journal*, Vol. 17 No.1, pp.5 - 18
21. Arumugam, V., Antony, J. and Douglas, A. (2012),"Observation: a Lean tool for improving the effectiveness of Lean Six Sigma", *The TQM Journal*, Vol. 24 No.3, pp.275 - 287
22. Assarlind, M., Gremyr, I. and Backman, K. (2012), "Multi-faceted views on a Lean Six Sigma application", *International Journal of Quality and Reliability Management*, Vol. 22 No. 3, pp. 21-30.
23. Bamber, G.J., Stanton, P., Bartram, T. and Ballardie, R. (2014),"Human resource management, Lean processes and outcomes for employees: towards a research agenda", *The International Journal of Human Resource Management*, Vol. 25 No.1, pp. 2881-2891
24. Banuelas, R., Antony, J., and Brace, M. (2005). An application of Six Sigma to reduce waste. *Quality and Reliability Engineering International*, 21(6), 553-570.
25. Barnes, C. and Walker, R. (2010),"Improving corporate communications: Lean Six Sigma science has broad reach", *Journal of Business Strategy*, Vol. 31 No.1, pp.23 - 36
26. Barney, M., 2002. Motorola's second generation. *Six Sigma Forum Magazine* 1 (3), 13–16.
27. Beck, M.J. and Gosik, K. (2015),"Redesigning an inpatient pediatric Services using Lean to improve throughput efficiency.", *Journal of hospital medicine*, Vol. 10 No.4
28. Bendell, T. (2005),"Structuring business process improvement methodologies", *Total Quality Management and Business Excellence*, Vol. 16 No. 8-9, pp.969-978
29. Bendell, T. (2006), "A review and comparison of six sigma and the lean organisations", *The TQM Magazine*, Vol. 18 No. 3, pp. 255-62.

30. Berger, R., 2013. Lean Management in the Financial Sector:. [Online] Available at: http://www.rolandberger.com/media/publications/2013-03-17-rb-sc-pub-Lean_management_in_the_financial_sector.html [Accessed 11 november 2013].
31. Bessant, John, Sarah Caffyn, and Maeve Gallagher (2001) "An evolutionary model of continuous improvement behaviour." *Technovation*, 67-77
32. Besseris, G. (2014), "Multi-factorial Lean Six Sigma product optimization for quality, leanness and safety", *International Journal of Lean Six Sigma*, Vol. 5 No. 3, pp.253 - 278
33. Bhamu, Jaiprakash and Kuldip Singh Sangwan.(2014) "Lean manufacturing: literature review and research issues." *International Journal of Operations and Production Management* 34.7 : 876-940.
34. Bhasin, Sanjay (2015), "Lean Management Beyond Manufacturing", Springer, NY
35. Bhat, S., Gijo, E.V. and Jnanesh, N.A. (2014), "Application of Lean Six Sigma methodology in the registration process of a hospital", *International Journal of Productivity and Performance Management*, Vol. 63 No.5, pp.613 - 643
36. Bicheno, J. (2004), *The New Lean Toolbox*, Picsie Books, Buckingham.
37. Bititci, U.S., Ackermann, F., Ates, A., Davies, J., Garengo, P., Gibb, S., MacBryde, J., Mackay, D., Maguire, C., van der Meer, R. and Shafti, F. (2011) "Managerial processes: business process that sustain performance" *International Journal of Operations & Production Management*, 31(8): 851-891.
38. Black, J. (2009), "Transforming the Patient Care Environment with Lean Six Sigma and Realistic Evaluation", *Journal for Healthcare Quality*, Vol. 31 No. 3, pp. 29–35.
39. Bowen, E.D. and Youngdahl, E.W. (1998), "'Lean' Services: in defense of a production-line approach", *International Journal of Services Industry Management*, Vol. 9 No. 3, pp. 207-225.
40. Braglia, M., Frosolini, M., and Zammori, F. (2009) "Uncertainty in value stream mapping analysis" *International Journal of Logistics: Research and Applications*, 12(6), 435-453.
41. Braverman, L.R. (2007), "BEST PRACTICES: Continuing Education's Role in Advancing Learning Organizations: The Center for Innovation in Lean and Six Sigma", *The Journal of Continuing Higher Education*, Vol. 55 No.2, pp. 17-22
42. Bullas, S. and Bryant, J. (2007), "Successful systems sustaining change.", *Studies in health technology and informatics*, Vol. 129 No.2, pp.1199-1203
43. Burgess, N. and Radnor, Z., 2013. Evaluating Lean in healthcare. *International Journal of Health Care Quality Assurance*, Vol. 26 No. 3, pp. 220-235.
44. Byrne, G., Lubowe, D. and Blitz, A. (2007), "Using a Lean Six Sigma approach to drive innovation", *Strategy and Leadership*, Vol. 35 No. 2, pp. 5–10.
45. Caldwell, C. (2006a), "A high quality of care: In health systems, achieving strategic results using lean Six sigma demands strong leadership", *IEEE Engineering Management Review*, Vol. 34 No.1
46. Caldwell, C. (2006b), "Lean-Six Sigma: tools for rapid cycle cost reduction.", *Healthcare financial management : journal of the Healthcare Financial Management Association*, Vol. 60 No.10, pp.96-108

47. Carboneau, C., Bengue, E., Jaco, M.T. and Robinson, M. (2010), "A lean Six Sigma team increases hand hygiene compliance and reduces hospital-acquired MRSA infections by 51%.", *Journal for healthcare quality : official publication of the National Association for Healthcare Quality*, Vol.32 No.4, pp. 61-70
48. Chaplin, L. and T.J. O'Rourke, S. (2014), "Lean Six Sigma and marketing: a missed opportunity", *International Journal of Productivity and Performance Management*, Vol. 63 No. 5, pp.665 - 674
49. Chassin, R. (2008), "The Six Sigma initiative at Mount Sinai Medical Center.", *The Mount Sinai journal of medicine*, Vol. 75 No. 1, pp. 45–52.
50. Chen, M. and Lyu, J. (2009), "A Lean Six-Sigma approach to touch panel quality improvement", *Production Planning and Control*, Vol. 20 No.5, pp. 445-454
51. Cheng, C.-Y. and Chang, P.-Y. (2012), "Implementation of the Lean Six Sigma framework in non-profit organisations: A case study", *Total Quality Management and Business Excellence*, Vol.23 No.3, pp. 431-447
52. Chiarini, A. (2011), "Japanese total quality control, TQM, Deming's system of profound knowledge, BPR, Lean and Six Sigma", *International Journal of Lean Six Sigma*, Vol. 2 No.4, pp.332 - 355
53. Chiarini, A. (2012), "Risk management and cost reduction of cancer drugs using Lean Six Sigma tools", *Leadership in Health Services*, Vol. 25 No. 4, pp. 318–330.
54. Chiarini, A. (2014), "A proposed audit pattern for the shop-floor processes in TQM, Lean Six Sigma and ISO 9001 environments", *International Journal of Services and Operations Management*, Vol. 18 No.2, pp.159-178
55. Chiarini, A. and Bracci, E. (2013), "Implementing Lean Six Sigma in healthcare: issues from Italy", *Public Money and Management*, Vol.3 No.5, pp.361-368
56. Clegg, B., Rees, C. and Titchen, M. (2010), "A study into the effectiveness of quality management training", *The TQM Journal*, Vol. 22 No.2, pp.188 - 208
57. Corbett, L.M. (2011), "Lean Six Sigma: the contribution to business excellence", *International Journal of Lean Six Sigma*, Vol. 2 No. 2, pp. 118–131.
58. Corning, P.A., (2002), "The re-emergence of emergence: A venerable concept in search of a theory", *Complexity*, 7(6), pp.18-30.
59. Dahlgaard, J.J. and Dahlgaard-Park, S.M. (2006), "Lean production, six sigma quality, TQM and company culture", *The TQM Journal*, Vol. 18 No.3, pp.263 - 281
60. Dahlgaard-Park, S.M., Chen, C.-K., Jang, J.-Y. and Dahlgaard, J.J. (2013), "Diagnosing and prognosticating the quality movement – a review on the 25 years quality literature 1987–2011", *Total Quality Management and Business Excellence*, Vol. 24 No.1, pp. 1-18
61. De Koeijer, R.J., Paauwe, J. and Huijsman, R. (2014), "Toward a conceptual framework for exploring multilevel relationships between Lean Management and Six Sigma, enabling HRM, strategic climate and outcomes in healthcare", *The International Journal of Human Resource Management*, Vol. 25 No. 21, pp. 2911–2925.
62. Delgado, C., Ferreira, M. and Branco, M.C. (2010), "The implementation of lean Six Sigma in financial Services organizations", *Journal of Manufacturing Technology Management*, Vol. 21 No. 4, pp. 512–523.

63. DelliFraine, J. L., Langabeer, J. R., and Nembhard, I. M. (2010). Assessing the evidence of Six Sigma and Lean in the health care industry. *Quality Management in Healthcare*, 19(3), 211-225.
64. Desai, D. A., Kotadiya, P., Makwana, N., and Patel, S. (2015) "Curbing variations in packaging process through Six Sigma way in a large-scale food-processing industry". *Journal of Industrial Engineering International*, 11(1), 119-129.
65. Díaz, A., Pons, J. and Solís, L., 2012. Improving healthcare Services: lean lessons from Aravind. *Int. J. Business Excellence*, Vol. 5, No. 4, p. 413–428.
66. Doman, M. S., 2011. A new lean paradigm in higher education: a case study.. *Quality Assurance in Education*, 19(3), pp. 248-262.
67. Dora, M. and Gellynck, X. (2015),"Lean Six Sigma Implementation in a Food Processing SME: A Case Study", *Quality and Reliability Engineering International*, doi: 10.1002/qre.1852.
68. Duarte, B., Montgomery, D., Fowler, J. and Konopka, J. (2012),"Deploying LSS in a global enterprise – project identification", *International Journal of Lean Six Sigma*, Vol. 3 No.3, pp.187 - 205
69. Elg, M., Gremyr, I., Hellström, A. and Witell, L. (2011),"The role of quality managers in contemporary organisations", *Total Quality Management and Business Excellence*, Vol. 22 No. 8, pp. 795–806.
70. Ellis, S.C., Goldsby, T.J., Bailey, A.M. and Oh, J.-Y. (2014),"Teaching Lean Six Sigma within A Supply Chain Context: The Airplane Supply Chain Simulation", *Decision Sciences Journal of Innovative Education*, Vol. 12 No. 4, pp. 287–319.
71. Elshennawy, A.K. (2004),"Quality in the New Age and the Body of Knowledge for Quality Engineers", *Total Quality Management and Business Excellence*, Vol. 15 No. 5-6, pp. 603–614.
72. Esimai, G. (2005). Lean Six Sigma reduces medication errors. *Quality progress*, 38(4), 51.
73. Fornari, A. and Maszle, G. (2004),"Lean Six Sigma Leads Xerox", *Six Sigma Forum Magazine*, Vol. 3 No. 4, pp. 11 – 16.
74. Found, P. and Harrison, R. (2012),"Understanding the lean voice of the customer", *International Journal of Lean Six Sigma*, Vol. 3 No. 3, pp. 251–267.
75. Franchetti, M. and Barnala, P. (2013),"Lean six sigma at a material recovery facility: a case study", *International Journal of Lean Six Sigma*, Vol. 4 No. 3, pp. 251–264.
76. Furterer, S. and Elshennawy, A.K. (2005),"Implementation of TQM and lean Six Sigma tools in local government: a framework and a case study", *Total Quality Management and Business Excellence*, Vol.16 No.10, pp. 1179-1191
77. Gamal Aboelimged, Mohamed.(2010) "Six Sigma quality: a structured review and implications for future research." *International Journal of Quality and Reliability Management* 27.3: 268-317
78. Gates. R(2007),"Deployment: start off on the right foot lean six sigma", *Quality Progress*,<http://www.asq.org/quality-progress/2007/08/lean/deployment-start-off-on-the-right-foot.pdf>

79. Geier, J. (2011), "Embedding Lean Six Sigma into everyday use ensures sustainable culture change at Xerox", *Global Business and Organizational Excellence*, 30: 17–26. doi: 10.1002/joe.20402
80. George (2003), *Lean Six Sigma for Services: How to Use Lean Speed and Six Sigma Quality to Improve Services and Transactions*. McGraw-Hill: USA
81. George Michael, L. (2002) "Lean Six Sigma: Combining Six Sigma Quality with Lean Speed."
82. Gibbons, P.M. and Burgess, S.C. (2010), "Introducing OEE as a measure of lean Six Sigma capability", *International Journal of Lean Six Sigma*, Vol. 1 No. 2, pp. 134–156.
83. Gibbons, P.M., Kennedy, C., Burgess, S. and Godfrey, P. (2012), "The development of a value improvement model for repetitive processes VIM", *International Journal of Lean Six Sigma*, Vol. 3 No. 4, pp.315 - 338
84. Gijo, E. V. and Antony, J. (2013), "Reducing patient waiting time in outpatient department using lean six sigma methodology", *Quality and Reliability Engineering International*, Vol. 26 No. 4, pp. 253–267.
85. Goh, T. N. (2002). A strategic assessment of Six Sigma. *Quality and Reliability Engineering International*, 18(5), 403-410.
86. Goh, T.N. (2011), "Six Triumphs and Six Tragedies of Six Sigma", *Quality Engineering*, Vol. 22 No. 4, pp. 299–305.
87. Goldis, A.L. (2013), "Selection of problem solving techniques and their popularity among internet users", *International Journal of Lean Six Sigma*, Vol. 4 No. 4, pp. 348–354.
88. Guarraia, P., Carey, G., Corbett, A. and Neuhau, K. (2008), *Lean Six Sigma for the Services Industry*, Bain and Company, Boston, MA
89. Hatzakis, E. D. M., Nair, S. K., and Pinedo, M. (2010). "Operations in financial Services—An overview". *Production and Operations Management*, 19(6), 633-664.
90. Heckl, D., Moormann, J. and Rosemann, M. (2010), "Uptake and success factors of Six Sigma in the financial Services industry", *Business Process Management Journal*, Vol. 16 No. 3, pp. 436-72
91. Hess, J.D. and Benjamin, B. a. (2015), "Applying Lean Six Sigma within the university: opportunities for process improvement and cultural change", *International Journal of Lean Six Sigma*, Vol. 6 No.3, pp.249 - 262
92. Hilton, R.J. and Sohal, A. (2012), "A conceptual model for the successful deployment of Lean Six Sigma", *International Journal of Quality and Reliability Management*, Vol. 29 No.1, pp.54 - 70
93. Hindo, B., 2007. At 3M, a struggle between efficiency and creativity. *Business Week* (August), 8–14.
94. Hines, P., Holweg, M. and Rich, N. (2004), "Learning to evolve: a review of contemporary lean thinking", *International Journal of Operations and Production Management*, Vol. 24 No. 10, pp. 994-1011.
95. Hoerl, R. W., and Gardner, M. M. (2010). *Lean Six Sigma, creativity, and innovation*. *International Journal of Lean Six Sigma*, 1(1), 30-38.

96. Hoerl, R.W. (2001), "Six sigma black belts: what do they need to know?", *Journal of Quality Technology*, Vol. 33 No. 4, pp. 391-435 (with discussion).
97. Hoerl, R.W. and Gardner, M.M. (2010), "Lean Six Sigma, creativity, and innovation", *International Journal of Lean Six Sigma*, Vol. 1 No. 1, pp. 30–38.
98. Holden, R. J. H. G., 2012. From group work to teamwork: A case study of "Lean" rapid process improvement in the ThedaCare Information Technology Department. *IIE Transactions on Healthcare Systems Engineering*, 2(3), pp. 190-201.
99. Holmes, M.C., Kumar, A. and Jenicke, L.O. (2005), "Improving the effectiveness of the academic delivery process utilizing six sigma", *Issues in Information Systems*, Vol. 2 No. 1, pp. 353-9
100. IBEF (2015), <http://www.ibef.org/industry/Services.aspx>
101. Improta, G., Balato, G., Romano, M., Carpentieri, F., Bifulco, P., Alessandro Russo, M., Rosa, D., et al. (2015), "Lean Six Sigma: a new approach to the management of patients undergoing prosthetic hip replacement surgery.", *Journal of evaluation in clinical practice*, Vol. 21 No. 4, pp. 662–72.
102. Isaksson, R., Kuttainen, C. and Garvare, R., 2013. *Lean Higher Education And Lean Research..* Verona, Retrieved from <http://www.diva-portal.org/smash/record.jsf?pid=diva2:683756>.
103. Janet H Sanders, T.K. (2015), "Improving ED specimen TAT using Lean Six Sigma", *International Journal of Health Care Quality Assurance*, Vol. 28 No. 5, pp. 428–440.
104. Jayaraman, K., Kee, T.L. and Soh, K.L. (2012), "The perceptions and perspectives of Lean Six Sigma practitioners", *The TQM Journal*, Vol. 24, No. 5, pp.433 - 446
105. Jenica, P.A., Mihai, D. and Sorin, A. (2010), "Using Lean Six Sigma as a Motivational Tool for Processes Improvement", *Annals of the University of Oradea*, Vol. 19 No. 2, pp. 438 – 442.
106. Jeyaraman, K. and Teo, L.K. (2010), "A conceptual framework for critical success factors of lean Six Sigma", *International Journal of Lean Six Sigma*, Vol. No.3, pp.191 - 215
107. Jovanović, R., Delić, M., Kamberović, B., Vulcanović, S. and Radlovački, V. (2013), "Planning the use of lean six sigma as a framework for blood bank management improvements", *International Journal of Industrial Engineering and Management*, Vol. 4 No. 4, pp. 237 – 244.
108. Kanakana, M. G., Pretorius, J. H., and van Wyk, B. J. (2012). "Applying lean Six Sigma in engineering education at Tshwane University of Technology". In *Proceedings of the 2012 International Conference on Industrial Engineering and Operations Management* (pp. 211-220).
109. Kanigolla, D., Cudney, E. a and Corns, S.M. (2014), "Enhancing engineering education using project-based learning for Lean and Six Sigma", *International Journal of Lean Six Sigma*, Vol. 5 No. 1, pp. 45–61.
110. Karthi, S., Devadasan, S., Selvaraju, K., Sreenivasa, C.G. and Sivaram, N.M. (2014), "Transforming into a Lean Six Sigma Enterprise Through ISO 9001 Standard-

- Based Quality Management System", *Journal of Enterprise Transformation*, Vol. 4 No. 2, pp. 100–122.
111. Karthi, S., Devadasan, S.R. and Muruges, R. (2011), "Integration of Lean Six-Sigma with ISO 9001:2008 standard", *International Journal of Lean Six Sigma*, Vol. 2 No. 4, pp. 309–331.
 112. Karthi, S., Devadasan, S.R., Selvaraju, K., Sivaram, N.M. and Sreenivasa, C.G. (2013), "Implementation of Lean Six Sigma through ISO 9001:2008 based QMS: a case study in a textile mill", *The Journal of The Textile Institute*, Vol. 104 No. 10, pp. 1089–1100.
 113. Kheradia, A. (2011), "TALEVAS model: an integrated quality methodology", *The TQM Journal*, Vol. 23 No. 4, pp. 403–422.
 114. Kim, D. S. (2010). "Eliciting success factors of applying Six Sigma in an academic library". *Performance Measurement and Metrics*, 11(1), 25-38.
 115. Kondo, Y., (1998) "Hoshin kanri-a participative way of quality management in Japan", *The TQM Magazine*, 10(6), pp.425-431.
 116. Koning, H. De and Does, R.J.M.M. (2008), "Lean Six Sigma in financial Services ", *International Journal of Six Sigma and Competitive Advantage*, Vol.4 No.1, pp.1-17
 117. Koning, H. de, Does, R.J.M.M., Groen, A., Kemper, B.P.H., de Koning, H., Does, R.J.M.M., Groen, A., et al. (2010), "Generic Lean Six Sigma project definitions in publishing", *International Journal of Lean Six Sigma*, Vol. 1 No. 1, pp. 39–55.
 118. Koning, H., Verver, J.P.S., Heuvel, J., Bisgaard, S. and Does, R.J.M.M. (2006), "Lean Six Sigma in Healthcare", *Journal for Healthcare Quality*, Vol. 28 No. 2, pp. 4–11.
 119. Kornfeld, B. and Kara, S. (2013), "Selection of Lean and Six Sigma projects in industry", *International Journal of Lean Six Sigma*, Vol. 4 No. 1, pp. 4–16.
 120. Kreuzer, E., Schäfer, A. and Aschbacher, H., 2011. *The Concept of Services Strategy Scorecard - an Integrated Approach for Lean Services Engineering and Services Improvement*
 121. Kumar, M. and Antony, J. (2008), "Comparing the quality management practices in UK SMEs", *Industrial Management and Data Systems*, Vol. 108 No. 9, pp. 1153–1166.
 122. Kumar, M., Antony, J. and Douglas, A. (2009), "Does size matter for Six Sigma implementation?", *The TQM Journal*, Vol. 21 No. 6, pp. 623–635.
 123. Kumar, M., Antony, J., Singh, R.K., Tiwari, M.K. and Perry, D. (2006), "Implementing the Lean Sigma framework in an Indian SME: a case study", *Production Planning and Control*, Vol. 17 No. 4, pp. 407–423.
 124. Kumar, S., Choe, D. and Venkataramani, S. (2012), "Achieving customer Services excellence using Lean Pull Replenishment", *International Journal of Productivity and Performance Management*, Vol. 62 No. 1, pp. 85–109.
 125. Kunonga. E .. Whitty P. and Singleton S. (2010). The applicability of hoshin kanri for strategic planning and deployment in the public sector: a case study from NHS North East. *journal of Management & Marketing in Healthcare*, 3(1). 87-97

126. Ladhari, R., (2009). Services quality, emotional satisfaction, and behavioural intentions: A study in the hotel industry. *Managing Services Quality*, 19 (3), 308 - 331.
127. LaGanga, L. R., 2011. Lean Services operations: Reflections and new directions for capacity expansion in outpatient clinics. *Journal of Operations Management*, 29(5), p. 422–433.
128. Langabeer, J.R., DelliFraine, J.L., Heineke, J. and Abbass, I. (2009),"Implementation of Lean and Six Sigma quality initiatives in hospitals: A goal theoretic perspective", *Operations Management Research*, Vol. 2 No. 1-4, pp. 13–27.
129. Langstrand, J., Cronemyr, P. and Poksinska, B. (2014),"Practise what you preach: quality of education in education on quality", *Total Quality Management and Business Excellence*,
130. Laureani, A. and Antony, J. (2010),"Reducing employees' turnover in transactional Services: a Lean Six Sigma case study", *International Journal of Productivity and Performance Management*, Vol. 59 No. 7, pp. 688–700.
131. Laureani, A. and Antony, J. (2011),"Standards for Lean Six Sigma certification", *International Journal of Productivity and Performance Management*, Vol. 61 No. 1, pp. 110–120.
132. Laureani, A. and Antony, J. (2012),"Critical success factors for the effective implementation of Lean Sigma", *International Journal of Lean Six Sigma*, Vol. 3 No. 4, pp. 274–283.
133. Laureani, A., and Antony, J (2015): Leadership characteristics for Lean Six Sigma, *Total Quality Management and Business Excellence*, DOI:10.1080/14783363.2015.1090291
134. Laureani, A., Antony, J. and Douglas, A. (2010),"Lean six sigma in a call centre: a case study", *International Journal of Productivity and Performance Management*, Vol. 59 No. 8, pp. 757–768.
135. Laureani, A., Brady, M. and Antony, J. (2013),"Applications of Lean Six Sigma in an Irish hospital", *Leadership in Health Services*, Vol. 26 No. 4, pp. 322–337.
136. Lee, K.K., Ree, S. and Park, Y.H. (2005),"A Study of Lean DFSS through the Creative Value Design", *Asian Journal on Quality*, Vol. 6 No. 3, pp. 121–131.
137. Lertwattanapongchai, S. and William Swierczek, F. (2014),"Assessing the change process of Lean Six Sigma: a case analysis", *International Journal of Lean Six Sigma*, Vol. 5 No. 4, pp. 423–443.
138. Less, O. (2005),"Lean six sigma reduces medication errors", *QUALITY PROGRESS*, Vol. 38 No. 4, p51
139. Lokkerbol, J., Does, R., Mast, J. de and Schoonhoven, M. (2012)," Improving processes in financial Services organizations: where to begin?", *International Journal of Quality and Reliability Management*, Vol. 29 No.9, pp.981 - 999
140. Mabin, V. J., and Balderstone, S. J., (2003) "The performance of the theory of constraints methodology: Analysis and discussion of successful TOC applications", *International Journal of Operations & Production Management*, Vol. 23 Iss: 6, pp.568 – 595

141. Madu, C.N. (2014), "Disaster relief supply chain quality management", *International Journal of Quality and Reliability Management*, Vol. 31 No.9, pp.1052 - 1067
142. Maguad, B.A. (2006), "The modern quality movement: Origins, development and trends", *Total Quality Management and Business Excellence*, Vol. 17 No.2, pp.179-203
143. Majer, H. (2007), "Technology measurement: the functional approach", *Technological Forecasting and Social Change*, Vol. 27, pp. 33-51.
144. Maleyeff, J., Edward A., and Venkateswaran, V. (2012) "The continuing evolution of Lean Six Sigma", *The TQM Journal*, Vol. 24 Iss: 6, pp.542 - 555
145. Malik, A. and Blumenfeld, S. (2012), "Six Sigma, quality management systems and the development of organisational learning capability", *International Journal of Quality and Reliability Management*, Vol. 29 No. 1, pp. 71–91.
146. Malladi, S., Dominic, P. and Kamil, A., 2011. Lean principles in IT Services: a case study on implementation and best practices. *Int. J. Business Information Systems*, Vol.8, No.3,, pp. 247-268.
147. Manville, G., Greatbanks, R., Krishnasamy, R., and Parker, D. W. (2012). Critical success factors for Lean Six Sigma programmes: a view from middle management. *International Journal of Quality and Reliability Management*, 29(1), 7-20.
148. Marcus, A and Lise, A(2013), "Forces affecting one Lean Six Sigma adoption process", *International Journal of Lean Six Sigma*, Vol. 5 No. 3, pp. 1–16.
149. Marti, F. (2005), "Lean Six Sigma method in Phase 1 clinical trials: a practical example", *The Quality Assurance Journal*, Vol. 9 No. 1, pp. 35–39.
150. Martinez, D. and Gitlow, H.S. (2011), "Optimizing employee time in a purchasing department: a Six Sigma case study", *International Journal of Lean Six Sigma*, Vol. 2 No. 2, pp. 180–190.
151. McAdam, R., Shirley-Ann Hazlett, Galbraith, B., (2014) "The role of performance measurement models in multi level alignment: An exploratory case analysis in the utilities sector", *International Journal of Operations and Production Management*, Vol. 34 Iss: 9, pp.1153 - 1183
152. McLean, R. and Antony, J. (2014), "Why continuous improvement initiatives fail in manufacturing environments? A systematic review of the evidence", *International Journal of Productivity and Performance Management*, Vol. 63 No. 3, pp. 370–376.
153. Meredith, J. O. et al., 2011. Are we operating effectively? A lean analysis of operating theatre changeovers. *Operations Management Research*, 4(3-4), 89–98. doi. *Operations Management Research*, 4(3-4),, p. 89–98.
154. Meza, D. and Jeong, K.-Y. (2013), "Measuring efficiency of lean six sigma project implementation using data envelopment analysis at Nasa", *Journal of Industrial Engineering and Management*, Vol. 6 No. 2, doi:10.3926/jiem.582.
155. Miguel, P.A.C. and Carvalho, M.M. De. (2014), "Benchmarking Six Sigma implementation in Services companies operating in an emerging economy", *Benchmarking: An International Journal*, Vol. 21 No. 1, pp. 62–76.

156. Mika, G. (2006), "Six Sigma isn't lean", *Manufacturing Engineering*, Vol. 137 No. 1.
157. Mohsen, F., Mohamed, I. and Mumtaz, U(2015), "Improving university facilities Services using Lean Six Sigma : a case study", *Journal of Facilities Management*, Vol. 13 No.1, pp.70 - 84
158. Montgomery, D.C. (2010), "A modern framework for achieving enterprise excellence", *International Journal of Lean Six Sigma*, Vol. 1 No. 1, pp. 56–65.
159. Morrow, E., Robert, G., Maben, J. and Griffiths, P., 2012. Implementing large-scale quality improvement: Lessons from The Productive Ward: Releasing Time to Care™. *International Journal of Health Care Quality Assurance*, 25(4), p. 237–253.
160. Muller-Merbach, H. (1976) "The Use of Morphological Techniques for OR- Approaches to Problems. In: *Operations Research*" Amsterdam, New York, Oxford. North-Holland publishing company, pp. 127-139
161. Murphy, S.A. (2009), "Leveraging lean Six Sigma to culture, nurture, and sustain assessment and change in the academic library environment", *College and Research Libraries*, Vol. 70.
162. Nabhani, F. and Shokri, A. (2009), "Reducing the delivery lead time in a food distribution SME through the implementation of six sigma methodology", *Journal of Manufacturing Technology Management*, Vol. 20 No. 7, pp. 957–974.
163. Nakhai, B., Neves, J.S., 2009. The challenges of Six Sigma in improving Services quality. *International Journal of Quality and Reliability Management* 26 (7), 663–684.
164. Naslund, (2008) "Lean, six sigma and lean sigma: fads or real process improvement methods?", *Business Process Management Journal*, Vol. 14 Iss: 3, pp.269 - 287
165. Näslund, D. (2013), "Lean and six sigma – critical success factors revisited", *International Journal of Quality and Services Sciences*, Vol. 5 No. 1, pp. 86–100.
166. Nicholas, J., 2016. Hoshin kanri and critical success factors in quality management and lean production. *Total Quality Management & Business Excellence*, 27(3-4), pp.250-264.
167. Nicolay, C.R., Purkayastha, S., Greenhalgh, A., Benn, J., Chaturvedi, S., Phillips, N. and Darzi, A. (2012), "Systematic review of the application of quality improvement methodologies from the manufacturing industry to surgical healthcare.", *The British journal of surgery*, Vol. 99 No. 3, pp. 324–35.
168. Nicoletti, B. (2013), "Lean Six Sigma and digitize procurement", *International Journal of Lean Six Sigma*, Vol. 4 No. 2, pp. 184–203.
169. Niemeijer, G.C., Flikweert, E., Trip, A., Does, R.J.M.M., Ahaus, K.T.B., Boot, A.F. and Wendt, K.W. (2013), "The usefulness of lean six sigma to the development of a clinical pathway for hip fractures.", *Journal of evaluation in clinical practice*, Vol. 19 No. 5, pp. 909–14.
170. Niemeijer, G.C., Trip, A., de Jong, L.J., Wendt, K.W. and Does, R.J.M.M. (2012), "Impact of 5 years of lean six sigma in a University Medical Center.", *Quality management in health care*, Vol. 21 No. 4, pp. 262–8.

171. Nonthaleerak, P. and Hendry, L., (2008) "Exploring the six sigma phenomenon using multiple case study evidence". *International Journal of Operations & Production Management*, 28(3), pp.279-303.
172. Nonthaleerak, P., Preeprem, and Linda Hendry. "Exploring the six sigma phenomenon using multiple case study evidence." *International Journal of Operations and Production Management* 28.3 (2008): 279-303.
173. Oshry, Barry. *Seeing systems: Unlocking the mysteries of organizational life*. Berrett-Koehler Publishers, 2007.
174. Ozcelik, Y. (2010). "Six Sigma implementation in the Services sector: notable experiences of major firms in the USA". *International Journal of Services and Operations Management*, 7(4), 401-418.
175. Pacheco, D., Pergher, I., Vaccaro, G.L.R., Jung, C.F. and ten Caten, C. (2015), "18 comparative aspects between Lean and Six Sigma", *International Journal of Lean Six Sigma*, Vol. 6 No. 2, pp. 161–175.
176. Pal Pandi, A., Rajendra Sethupathi, P. V and Jeyathilagar, D. (2014), "The IEQMS model for augmenting quality in engineering institutions – an interpretive structural modelling approach", *Total Quality Management and Business Excellence*,
177. Panat, R., Dimitrova, V., Selvy Selvamuniandy, T., Ishiko, K. and Sun, D. (2014), "The application of Lean Six Sigma to the configuration control in Intel's manufacturing RandD environment", *International Journal of Lean Six Sigma*, Vol. 5 No. 4, pp. 444–459.
178. Pande, P., Neuman, R., and Cavanagh, R. (2000). *The Six Sigma way: How GE, Motorola and other top companies are honing their performance*. New York, NY: McGraw-Hill Professional
179. Parker, M. and Slaughter, J. (1994), "Lean production is mean production: TQM equals management by stress", *Canadian Dimension*, Vol. 28 No. 1, p. 21.
180. Parris, A. (2013), "Improving processes for good in East Africa", *The TQM Journal*, Vol. 25 No. 5, pp. 458–472.
181. Patyal, V.S. and Koilakuntla, M. (2015), "Infrastructure and core quality practices in Indian manufacturing organizations", *Journal of Advances in Management Research*, Vol. 12 No. 2, pp. 141–175.
182. Pepper, M.P.J. and Spedding, T.A. (2010), "The evolution of lean Six Sigma", *International Journal of Quality and Reliability Management*, Vol. 27 No. 2, pp. 138–155.
183. Peteros, R.G. and Maleyeff, J. (2015), "Using Lean Six Sigma to improve investment behavior", *International Journal of Lean Six Sigma*, Vol. 6 No. 1, pp. 59–72.
184. Pillai, A.K.R., Pundir, A.K. and Ganapathy, L. (2012), "Implementing Integrated Lean Six Sigma for Software Development: A Flexibility Framework for Managing the Continuity: Change Dichotomy", *Global Journal of Flexible Systems Management*, Vol. 13 No. 2, pp. 107–116.
185. Porter, M. E. (2011). *Competitive advantage of nations: creating and sustaining superior performance*. Simon and Schuster.

186. Pranoto, S., and Nurcahyo, R. (2014). "Implementation of integrated system Six Sigma and importance performance analysis for quality improvement of HSDPA telecommunication network and customer satisfaction". In Proceedings of the 2014 International Conference on Industrial Engineering and Operations Management.
187. Prasad, K. D., Subbaiah, K. V., and Padmavathi, G. (2012). "Application of Six Sigma methodology in an engineering educational institution". *Int. J. Emerg. Sci*, 2(2), 222-237.
188. Prasanna, M. and Vinodh, S. (2013), "Lean Six Sigma in SMEs: an exploration through literature review", *Journal of Engineering*, Vol. 11 No. 3, pp. 224–250.
189. Psychogios, A.G. and Tsironis, L.K. (2012), "Towards an integrated framework for Lean Six Sigma application: Lessons from the airline industry", *Total Quality Management and Business Excellence*, Vol. 23 No. 3-4, pp. 397–415.
190. Qin, H., Prybutok, V. R., and Zhao, Q. (2010). Perceived Services quality in fast-food restaurants: empirical evidence from China. *International Journal of Quality and Reliability Management*, 27(4), 424-437.
191. Radnor (2010), Transferring Lean into government. *Journal of Manufacturing Technology Management*, 21(3), p. 411–428.
192. Radnor, Z. (2011), "Implementing Lean in health care: making the link between the approach, readiness and sustainability", *International Journal of Industrial Engineering and Management*, 2(1):1-12.
193. Radnor, Z. and Johnston, R., (2013) "Lean in UK Government: internal efficiency or customer Services?" *Production Planning and Control*, 24(10-11): 903-915.
194. Rao, Jaya (2011), "Best Buy: Merging Lean Sigma with Innovation", *Harvard Business Review*, <https://hbr.org/product/best-buy-merging-lean-sigma-with-innovation/an/BAB697-PDF-ENG>
195. Ray, S. and John, B. (2011), "Lean Six-Sigma application in business process outsourced organization", *International Journal of Lean Six Sigma*, Vol. 2 No. 4, pp. 371–380.
196. Ritchey, T. (2011), *Wicked Problems – Social Messes, Risk, Governance and Society*, Springer Publications, Berlin-Heidelberg.
197. Rodica Pamfiliea , Andreea Jenica Petcu, M.D. (2012), "The Importance of Leadership in Driving a Strategic Lean Six Sigma Management", *Procedia - Social and Behavioral Sciences*, Vol. 58, pp. 187–196.
198. Sahay, P. (2015), "Lean Six Sigma tools in the hiring process", *Strategic HR Review*, Vol. 14 No. 1/2, pp. 22–29.
199. Salah, S., Rahim, A. and Carretero, J.A. (2010), "The integration of Six Sigma and lean management", *International Journal of Lean Six Sigma*, Vol. 1 No. 3, pp. 249–274.
200. Sarkar, A., Mukhopadhyay, A.R. and Ghosh, S.K. (2011), "Selection of critical processes for 'process improvement'", *International Journal of Lean Six Sigma*, Vol. 2 No. 4, pp. 356–370.
201. Sarkar, S., Ranjan Mukhopadhyay, A., Ghosh, S.K., Sarkar, S.A., Mukhopadhyay, A.R. and Ghosh, S.K. (2013), "Improvement of claim processing

- cycle time through Lean Six Sigma methodology", *International Journal of Lean Six Sigma*, Vol. 4 No.2, pp.171 - 183
202. Sarkar, S.A., Mukhopadhyay, A.R., Ghosh, S.K., Ashok Sarkar, S., Ranjan Mukhopadhyay, A., Ghosh, S.K., Sarkar, S.A., et al. (2013), "Root cause analysis, Lean Six Sigma and test of hypothesis", *The TQM Journal*, Vol. 25 No. 2, pp. 170–185.
 203. Scherrer-Rathje, Maïke, Todd A. Boyle, and Patricia Deflorin. "Lean, take two! Reflections from the second attempt at lean implementation." *Business Horizons* 52.1 (2009): 79-88.
 204. Schroeder, R.G., Linderman, K., Liedtke, C., Choo, A.S., 2008. Six Sigma: definition and underlying theory. *Journal of Operations Management* 26, 536–554.
 205. Setijono, D. and Dahlgaard, J.J. (2007), "The Added-Value Metric - A Complementary Performance Measure for Six Sigma and Lean Production", *Asian Journal on Quality*, Vol. 8 No. 1, pp. 1–14.
 206. Shah, R., Chandrasekaran, A. and Linderman, K. (2008), "In pursuit of implementation patterns: the context of Lean and Six Sigma", *International Journal of Production Research*, Vol. 46 No. 23, pp. 6679–6699.
 207. Sharma, U. (2004), "Implementing lean principles with the Six Sigma advantage: how a battery company realized significant improvements", *Journal of Organizational Excellence*, Vol. 22 No. 3, pp. 43-52
 208. Shingo, S. (1988), *Non-Stock Production: The Shingo System for Continuous Improvement*, Productivity Press, Cambridge, MA.
 209. Shokri, a and Nabhani, F. (2015), "LSS, a problem solving skill for graduates and SMEs: case study of investigation in a UK business school curriculum", *International Journal of Lean Six Sigma*, Vol. 6 No. 2, pp. 176–202.
 210. Simon Majaro, (1988), "MORPHOLOGICAL ANALYSIS", *Marketing Intelligence and Planning*, Vol. 6 Iss 2 pp. 4 – 11
 211. Singh, Jagdeep, and Harwinder Singh. (2015) "Continuous improvement philosophy—literature review and directions." *Benchmarking: An International Journal* 22.1 : 75-119.
 212. Smith, B. (2003), "Lean and Six Sigma – a one-two punch", *Quality Progress*, Vol. 36 No. 4, pp. 37-41.
 213. Snee, R.D. (2010), "Lean Six Sigma – getting better all the time", *International Journal of Lean Six Sigma*, Vol. 1 No. 1, pp. 9-29
 214. Snee, R.D. and Hoerl, R.W. (2007), "Integrating Lean and Six Sigma — a Holistic Approach", *Six Sigma Forum Magazine*, Vol. 6 No. 3, pp. 15 – 21.
 215. Spear, S.J. (2004), "Learning to lead at Toyota", *Harvard Business Review*, Vol. 82 No. 5, p. 78.
 216. Staats, B., Brunner, J. B. and Upton, D., 2011. Lean principles, learning, and knowledge work: Evidence from a software Services. *Journal of Operations Management*, 29(5), p. 376–390.
 217. Stanton, P., Gough, R., Ballardie, R., Bartram, T., Bamber, G.J. and Sohal, A. (2014), "Implementing lean management/Six Sigma in hospitals: beyond

- empowerment or work intensification?", *The International Journal of Human Resource Management*, Vol. 25 No. 21, pp. 2926–2940.
218. Stuenkel, K. and Faulkner, T. (2009), "A community hospital's journey into Lean Six Sigma.", *Frontiers of health Services management*, Vol. 26 No. 1, pp. 5–13.
219. Su, C. T., Chiang, T. L., and Chang, C. M. (2006). Improving Services quality by capitalising on an integrated Lean Six Sigma methodology. *International Journal of Six Sigma and Competitive Advantage*, 2(1), 1-22.
220. Sudhindra , L.S. Ganesh , K. Arshinder , (2014) "Classification of supply chain knowledge: a morphological approach", *Journal of Knowledge Management*, Vol. 18 Iss: 4, pp.812 - 823
221. Svensson, C., Antony, J., Ba-Essa, M., Bakhsh, M., and Albliwi, S. (2015). A Lean Six Sigma program in higher education. *International Journal of Quality and Reliability Management*, 32(9), 951-969.
222. Swink, Morgan, and Brian W. Jacobs. "Six Sigma adoption: Operating performance impacts and contextual drivers of success." *Journal of Operations Management* 30.6 (2012): 437-453.
223. Teece, David; Pisano, Gary; Shuen, Amy (August 1997). Dynamic Capabilities and Strategic Management "Dynamic Capabilities and Strategic Management" *Strategic Management Journal* 18 (7): 509–533.
224. Tenera, A. and Pinto, L.C. (2014), "A Lean Six Sigma Project Management Improvement Model", *Procedia - Social and Behavioral Sciences*, Vol.119, pp.912-920
225. Thawani, S. (2004). Six sigma—strategy for organizational excellence. *Total Quality Management and Business Excellence*, 15(5-6), 655-664.
226. Thawesaengskulthai, N. and Tannock, J.D.T. (2008), "Pay-off selection criteria for quality and improvement initiatives", *International Journal of Quality and Reliability Management*, Vol. 25 No. 4, pp. 366–382.
227. Thomas, A., Barton, R. and Chuke-Okafor, C. (2008), "Applying lean six sigma in a small engineering company – a model for change", *Journal of Manufacturing Technology Management*, Vol. 20 No. 1, pp. 113–129.
228. Timans, W., Ahaus, K., van Solingen, R., Kumar, M. and Antony, J. (2014), "Implementation of continuous improvement based on Lean Six Sigma in small- and medium-sized enterprises", *Total Quality Management and Business Excellence*, DOI:10.1080/14783363.2014.980140
229. Tolga Taner, M., Sezen, B., and Antony, J. (2007). An overview of six sigma applications in healthcare industry. *International Journal of health care quality assurance*, 20(4), 329-340.
230. Toussaint, J. S. and Berry, L. L., 2013. The Promise of Lean in Health Care.. *Mayo Clinic Proceedings*, 88(1), pp. 74-82.
231. Tranfield, D., Denyer, D. and Smart, P. (2003), "Towards a methodology for developing evidence informed management knowledge by means of systematic review", *British Journal of Management*, Vol. 14 No. 3, pp. 207-222.
232. Umit S. Bititci, Fran Ackermann, Aylin Ates, John Davies, Patrizia Garengo, Stephen Gibb, Jillian MacBryde, David Mackay, Catherine Maguire, Robert van der Meer, Farhad Shafti, Michael Bourne, Seniye Umit Firat, (2011) "Managerial

- processes: business process that sustain performance", *International Journal of Operations and Production Management*, Vol. 31 Iss: 8, pp.851 - 891
233. Van Leeuwen, K. C. and Does, R. J. M. M., 2010. Quality Quandaries: Lean Nursing.. *Quality Engineering*, 23(1), pp. 94-99
 234. Vijaya Sunder, M. (2013), "Synergies of Lean Six Sigma", *IUP Journal of Operations Management*, Vol. 12 No. 1, pp. 21 – 31.
 235. Vijaya Sunder, M. (2014) 'Quality excellence in higher education system through Six Sigma: student team engagement model', *International Journal of Six Sigma and Competitive Advantage*, Vol. 8, Nos. 3/4, pp.247–256
 236. Vijaya Sunder, M. (2015), "Corporate perspectives: commonalities and differences between Six Sigma and Lean", *International Journal of Lean Six Sigma*, Vol. 6 No. 3, pp. 281–288.
 237. Vijaya Sunder, M. (2016) "Lean six sigma project management – a stakeholder management perspective", *The TQM Journal*, Vol. 28 Iss: 1, pp.132 - 150
 238. Vijaya Sunder, M. and Antony, J (2015). Six-Sigma for improving Top Box CSAT for a Banking Call Centre. *Production Planning and Control - Management of Operations*. Advance online publication. DOI: 10.1080/09537287.2015.1021879
 239. Wang, F.-K. and Chen, K.-S. (2010), "Applying Lean Six Sigma and TRIZ methodology in banking Services", *Total Quality Management and Business Excellence*, Vol. 21 No. 3, pp. 301–315.
 240. Wertheimer, M. and Riezler, K., (1944), "Gestalt theory", *Social Research*, pp.78-99.
 241. Witcher, B. and Butterworth, R., (1999) "Hoshin kanri: how Xerox manages", *Long Range Planning*, 32(3), pp.323-332.
 242. Womack, J. and Jones, D.T. (1996), *Lean Thinking: Banish Waste and Create Wealth for Your Corporation*, Simon and Schuster, New York, NY.
 243. Womack, J., Jones, D. and Roos, D. (1990), *The Machine that Changed the World*, Rawson Associates, New York, NY.
 244. Xin. L, Jiwu. W, Lucheng. H, Jiang. L, Jian. L, (2010) "Empirical research on the technology opportunities analysis based on morphology analysis and conjoint analysis", *Foresight*, Vol. 12 Iss: 2, pp.66 – 76
 245. Yuen, Kum Fai, and Van Vinh Thai. "Services quality and customer satisfaction in liner shipping." *International Journal of Quality and Services Sciences* 7.2/3 (2015).
 246. Zieger, A. (2009), "Lean, Six Sigma management becoming more popular at hospitals", *Fierce Health Finance*.
 247. Zorzini, Marta, et al. (2015) "Socially responsible sourcing: reviewing the literature and its use of theory." *International Journal of Operations and Production Management* 35.1: 60-109.
 248. Zwicky, F. (1969), *Discovery, Invention, Research-Through the Morphological Approach*, 1st ed., Macmillan, p. 276.

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Al-Hakim and Gong (2012)	Healthcare services	Reduction in operative time, medical errors and waiting lists utilisation of out-patient.
Díaz, et al., (2012)	Healthcare services	Balance demand and supply, cost efficiency, higher productivity
Morrow, et al., (2012)	Healthcare services	Improved quality of care, improved efficiency and patient's e
Berger (2013)	Banking and Financial services	Save time, positive effect on budget. More efficient processes increased at a lower rate than the volume of business.
Isaksson, et al., (2013)	Education services	Reduction in delivery time of knowledge, flexible speed of st size as per need.
Radnor and Johnston (2013)	Government services	Improved quality and productivity, clearer and standardised p
Burgess and Radnor (2013)	Healthcare services	Productivity improvement in English trust hospitals.
Chiarini (2013)	Healthcare services	Reduction in cost and the average lead time of the patient fro hospitalisation or discharge.
Toussaint and Berry (2013)	Healthcare services	Increase in on-time starts, decrease in operating room turnaroc rescheduled and in same-day surgery cancellations.

Table 2: A Sample of Research Publications on Success of Six Sigma in Services

Authors	Service Area	Benefits
Ozcelik (2010)	Banking and Financial services	Quality improvement in multiple major service firms in the U
Lifvergren et al., (2010)	Healthcare services	Organisational quality metrics success rate of 75% across 22
Ray et al.,(2011)	IT services	Reduction in the follow up time for customer complaint resol and decrease in the ratio of pending complaints
Pranoto et al.,(2014)	Call Centre services	Improved quality of call setup success rate from 98.44% to 9
Kanakana et al., (2012)	Education services	Increased the student engagement during normal lecturing w the subjects from 38% to 71%
Prasad et al., (2012)	Education services	Improved quality in engineering education and instilled quali students and the management
Hatzakis et al., (2010)	Banking and Financial services	Reduction in operational risk and improvement in operational
Vijaya Sunder et al., (2015)	Call Centre services	Improvement in customer satisfaction score of call centre
Qin et al., (2010)	Hospitality services	The results contribute to the understanding of service quality and provided insight about service management
Heckl et al., (2010)	Banking andFinanPIal services	Proven acceptance level of the Six Sigma methodology, the a factors that determine success
Tolga (2012)	Healthcare services	The most frequent causes of failure identified and improper p implemented with increased sigma level
Kim (2010)	Education services	Quality improvement in Sungkyunkwan University Library
Gijo et al., (2014)	Healthcare services	Reduction in longer patient waiting time in the outpatient dep specialty hospital
Desai et al., (2015)	Hospitality services	Key metric improvement and projected bottom-line gain to th

Table 3: Publications across journals

Journals	No. of papers	2003 to 200
International Journal of Lean Six Sigma	34	
Total Quality Management and Business Excellence	16	3
International Journal of Quality and Reliability Management	14	1
The TQM Journal	14	5

Research method	Theoretical			30	17%	Snee (2010), Maleyeff et al.
	Empirical	Primary data	Case Study/Action Research	66	38%	Franchetti and Furterer and Els Antony (2010)
			Questionnaire	12	7%	Douglas et al.
			Interviews	8	5%	Psychogiosand
			Viewpoints	5	3%	Antony (2011) (2011)
			Experiment data	2	1%	Besseris (2014)
	Secondary Data			24	14%	Albiwi et al.,
Mixed Methods			28	16%	Langabeer et al. Laureaniand A	

Table 5: Sector-wise classification of reviewed papers

		No. of papers	% papers	Sample papers
Generic across all service sectors		76	43%	Albliwi et al., (2014), Jayaraman et al., (2014), Antony (2011), Montgomery (2012), Shah et al., (2008)
Specific to a particular service sector	Healthcare	35	20%	Aldarrab (2006), Aleem (2013), Caldwell (2006), Carboneau et al. (2010)
	Education	14	8%	Langstrand et al., (2014), Heslop et al., (2014), Antony (2014), Antony (2014)
	Banking, financial services and insurance	7	4%	Wang and Chen (2010), Delgado et al. (2008), Lokkerbol et al., (2010)
	Information technology enabled services	5	3%	Byrne et al (2007), Pillai (2012)
	Airlines	4	2%	Psychogiosand Tsironis (2012)
	Telecom	3	2%	Barnes and Walker (2010), Lau et al. (2010)
	Food-Beverage services	3	2%	Nabhani and Shokri (2009),
	Non-profit services	2	1%	Cheng, and Chang (2012).
	Government services	2	1%	Furterer and Elshennawy (2005)
Others	8	5%	Koning et al., (2010), Chaplin et al. (2010)	
Services in manufacturing sectors		16	9%	Kumar et al., (2006), Timans et al. (2008), Thomas et al., (2008), Chen et al. (2008)

Table 6: Application of Lean Six Sigma across service sectors

Authors	Application of LSS through case studies/action research
<u>Airlines</u>	
Gibbons et al (2012)	Improved shuttle transport service, used to transport passengers between terminals at an airport
Arumugam et al (2012)	Improved security check process and the passenger experience, reduced the queue time and at an airport
Meza and Jeong (2013)	Improves operational efficiencies at Johnson Space Centre at NASA, based on Data Envelopment Analysis
<u>Banking, financial services and insurance</u>	
Koning and Does (2008)	Four case studies from Dutch multinational insurance companies showcasing breakthrough process improvements
Koning et al., (2008)	Highlighted the benefits of 65 LSS projects across 5 financial services organisations
Delgado et al., (2010)	Improved investment behaviour at GE Money. The benefits included lowering the operational costs and increased process efficiency
Heckl et al., (2010)	Process improvement benefits of 145 financial service companies from Germany, Switzerland, Austria and Great Britain
Sarkar et al., (2013)	Reduced cycle time in an insurance company
Peteros and Maleyeff (2015)	Improved decision making behaviour in self directed investors
<u>Education</u>	
Braverman (2007)	Creating learning capability by promoting innovation in LSS
Murphy (2009)	Improved a library process at the Ohio State University
Martinez and Gitlow (2011)	Resolved a staffing problem for a purchasing department at the University of Miami resulting in cost saving for the university
Ellis et al., (2014)	Improved students understanding in LSS concepts through Service Supply Chain simulation
Langstrand et al., (2014)	Benefits of effective course design and LSS related subjects in higher education curriculum in colleges
Kanigolla et al., (2014)	Importance and impact of project-based learning in LSS courses offered in colleges.
Shokri and Nabhani (2015)	Reduced the gap between the graduates of business schools as knowledge and skill bearers to the knowledge and skill users.
Mohsen et al., (2015)	Improved facilities services across University campuses
<u>Food-Beverage services</u>	
Nabhani and Shokri (2009)	Successfully promoted supply chain management objectives for a food distribution centre
Besseris (2014)	Application of LSS for PI in food processing based on two crucial characteristics for product safety
Dora and Gellynck (2015)	Application of LSS in a medium-sized confectionary for reducing variation and rework
<u>Government services</u>	
Furterer and Elshennawy (2005)	Improved quality and timeliness of providing local governmental services of a country
Franchetti and Barnala (2013)	Improved the processes and increased capacity for a government operated material recovery facility in Ohio, USA.
<u>Healthcare</u>	
Less (2005)	Healthcare case study focussed on reducing medication errors
Caldwell (2006a)	Improved the cost of poor quality and waste elimination in healthcare context
Chassin (2008)	Mount Sinai Medical Centre's experience adapting LSS to improve both patient care and business processes
Langabeer et al., (2009)	Provided the descriptive results in examining the effect of LSS in a cross-sectional sample of hospitals

Stuenkel and Faulkner (2009)	PI Cultural change through at Floyd Medical Centre community hospital has led to sustainable improvement results in process metrics
Nicolay et al., (2012)	Reduced infection rates and increased operating room efficiency
Chiarini (2012)	Risk reduction for health, safety and costs reduction inside pharmacy departments of a hospital
Niemeijer et al., (2012)	Experiences of Medical Center Groningen, Netherlands, highlighting the employee benefits achieved using LSS
Niemeijer et al., (2013)	Successful application of LSS methodology within the development of a clinical pathway for customer satisfaction
Gijoand Antony (2013)	Improved patient waiting time in the outpatient department of a super specialty hospital in India
Jovanovic et al., (2013)	Optimised the usage of blood products and minimised the wastage of outdated blood at a blood bank
Chiarini and Bracci (2013)	Examined ways of using LSS for process improvement in healthcare organizations in Italy
Laureani et al., (2013)	Process improvement at Irish hospital through LSS tools, techniques as an effective method for instigating process change
Bhat et al., (2014)	Application of LSS methodology in the registration process of a hospital
Beck and Gosik (2015)	Delivered consistent results, eliminating key-man dependency at a tertiary care children's hospital
Improta et al., (2015)	Improved quality and reduced cost in hospitals for patients undergoing prosthetic hip replacement surgery
Janet and Sanders (2015)	Reduction of turnaround time for emergency department of clinical lab system for the specimens
<u>Information technology enabled services</u>	
Byrne et al., (2007)	Highlights Caterpillar's success using LSS for innovation, by growing revenues by 80% in five years
Ray and John (2011)	Reduction in cycle time for IT outsourced organisations.
Duarte et al., (2012)	Through a focussed study, a total of 30% of the business processes were found to be LSS conducive in an IT based company
Nicoletti (2013)	Demonstrated how LSS method can be applied to information technology and communication systems
<u>Non-profit services</u>	
Cheng and Chang (2012)	Increased efficiency of resource management in physical disabilities services of a non-profit organisation by 70%
Parris (2013)	Cost reduction at an international non-governmental organisation in East Africa
<u>Telecom</u>	
Laureani et al., (2010)	Increase in first-call resolution ratio of a call centre using LSS
Kumar et al., (2012)	Cultural transformation at a telecom firm using LSS
Tenera and Pinto (2014)	Process improvement at a Portuguese telecommunication company though LSS, project management approach

Table 7: Morphological Analysis Framework

1. Organizational context of application (Based on Porter's value chain)		Primary activities						Short term/transactional outcomes						Tangible outcomes			Intangible outcomes			Enabler for Breakthrough and disruptive innovation					
		Inbound Logistics	Operations	Outbound Logistics	Marketing and Sales	Post Sale services	Procurement	Human Resource Management	Cost reduction	Increase in revenue	Risk Management	Quality and productivity improvement	Customer or Employee Satisfaction	Error reduction	Enabler for effective decision making environment	Enabler for Continuous improvement mind-set	Improved Competitiveness/Market share	Enabler for Breakthrough and disruptive innovation							
<ul style="list-style-type: none"> Improved shuttle transport service, used to transport passengers between terminals at an airport (Gibbons et al., 2012) Improved security check process and the passenger experience, reduced the queue time and at an airport (Arumugam et al., 2012) Application of LSS methodology in the registration process of a hospital (Bhat et al., 2014) 		<ul style="list-style-type: none"> LSS application in Airlines operations: (Meza and Jeong, 2013) Banking and Financial Services operations: (Koning and Does, 2008; Delgado et al., 2010; Heckl et al., 2010) Food-Beverage services (Bessaris, 2014; Dora and Gellynek, 2015) Healthcare services (Less, 2005; Caldwell, 2006; Stuenkel and Faulkner, 2009; Laureani et al., 2013) ITES operations (Ray and John, 2011; Duarte et al., 2012) 	<ul style="list-style-type: none"> Successfully promoted supply chain management objectives using LSS for a food distribution centre (Nabhanian and Shokri, 2009) LSS improved outpatient care post medication (Chassin, 2008; Langabeer et al., 2009) 	<ul style="list-style-type: none"> Importance and impact of project-based learning in LSS courses offered in colleges (Kanigolla et al., 2014) LSS deployment in various marketing opportunities (Chaplin, 2014) 	<ul style="list-style-type: none"> Reduced cycle time in claim processing of insurance companies (Sarkar et al., 2013) Increase in first-call resolution ratio of a call centre using LSS (Laureani et al., 2010) 	<ul style="list-style-type: none"> Resolved a staffing problem for a purchasing department at the University of Miami resulting in cost saving for the university (Martinez and Gitlow, 2011) 	<ul style="list-style-type: none"> Experiences of MedCenter Groningen, Netherlands, highlighting employee benefits achieved using LSS (Niemeijer et al., 2012) Increased efficiency in resource management in physical disabilities service a non-profit organisation by 70% (Cheng and Chang, 2005) 	<ul style="list-style-type: none"> LSS optimized the usage of blood products and minimized the wastage of outdated blood at a blood bank (Jovanovic et al., 2013) Highlights Caterpillar's success using LSS for innovation, by growing revenues by 80% in five years (Byrne et al., 2007) Cost reduction at an international non-governmental organisation in East Africa (Parris, 2013) Estimate of a cost-benefit ratio of 		<ul style="list-style-type: none"> Risk reduction for health, safety and costs inside pharmacy departments of a hospital (Chiarini, 2012) Delivered consistent results, eliminating key-man dependency at a tertiary care children's hospital (Beck and Gosik, 2015) 		<ul style="list-style-type: none"> Improved quality and reduced cost in hospitals for patients undergoing prosthetic hip replacement surgery (Improta et al., 2015) Demonstrate how LSS provides an excellent way to improve productivity and quality of financial services (Furter and Elshennawy, 2005) 		<ul style="list-style-type: none"> Successful application of LSS methodology within the development of a clinical pathway for customer satisfaction (Niemeijer et al., 2013) Customer service excellence at a telecom firm (Kumar et al., 2012) 		<ul style="list-style-type: none"> Demonstrates the application of LSS for error reduction in services (Esimai, 2005; Dellifraie et al., 2010; Tolga Banuelas et al., 2005) Service process can be slow and therefore costly and prone to error and therefore LSS becomes essential (Laureani and Antony, 2010) 		<ul style="list-style-type: none"> LSS has been recognized as a decision making platform in organizations (Goh, 2010; Scinto, 2011) Demonstrated the application of LSS in deciding the investment behavior of customers (Petros and Maleyeff, 2015) LSS proved to be a successful enabler for human resource development, improving strategic climate and promoting systems thinking (Bullas and Beyant, 2007; Stuenkel and Faulkner, 2009; Chiarini and Bracci, 2013; De Koeijer et al., 2014) 		<ul style="list-style-type: none"> LSS acts as a continuous improvement driver in service context for both manufacturing and service organisations (Fornari and Maszle, 2004; Dahlgaard and Dahlgaard, 2006; Gibbons and Burgess, 2010; Barnes and Walker, 2010; Geiger, 2011; Bamber et al., 2014; Murphy, 2009; Hess et al., 2015; Koning and Does, 2008; Koning et al., 2008) Highlighted the importance of formal classroom 'Belt' training for developing resources for successful LSS project management (Aileen, 2013) 		<ul style="list-style-type: none"> LSS strives to make organizations more competitive in market (Naslund, 2008) Argues that LSS help organizations to perform better in the competitive market environment (Armheiter and Mailey eff, 2005) The integrated LSS methodology helps improve service quality which further enables to improve the market share (Chiang and Chang, 2006) 		<ul style="list-style-type: none"> LSS recognized as a key driver for innovation in organisations (Byrne, 2007; Hoerland Gardner, 2010; Antony et al., 2014) Demonstrated how Best Buy and Intel apply LSS for Research and Development (Rao, 2011; Panat et al., 2014) DFSS approach of LSS helps in promoting innovation as a competitive strategy (Lee et al., 2005) 	
		<ul style="list-style-type: none"> 2. Desired Outcomes 																							

	<ul style="list-style-type: none"> Highlights case-studies where practicing lean for approximately 18 months was called to push the improvements further using Six Sigma (Smith, 2003) 	<p>Proposed continuous improvement based on Lean Six Sigma deployment method for small and medium sized enterprises (Kumar et al., 2011; Timans et al., 2014)</p> <ul style="list-style-type: none"> Outlines the benefits and synergies of combined LSS approach (Sheridan, 2000; ArnheterandMaleyeff, 2005; Bendell, 2006; Pepper Andersson et al., 2006; Pacheco, 2010; Salih et al., 2010; VijayaSunder, 2013) 	<ul style="list-style-type: none"> Lean and Six Sigma are often implemented in isolation for organizational benefits (Smith, 2003) Lean and Six sigma are incompatible with one another because Six Sigma cannot be embraced by the frontline employees (Mika, 2006) There exist distinct differences and commonalities between Lean and Six Sigma as parallels (Vijaya Sunder, 2015; Antony, 2011; Andersson et al., 2006; Pacheco, 2015; Kornfeld, 2013; Assarilind, 2012) 	<ul style="list-style-type: none"> Niche skills human resources like Master Black Belts and Black Belts are required for LSS deployments (Bendell, 2006), success of which further has a positive impact back on human resources of the firms (VijayaSunder, 2013) 	<ul style="list-style-type: none"> Right investment in LSS is required by service organizations and lack of financial resources could lead to failure of LSS programs (Antony, Kumar and Madu, 2005; Antony, Kumar and Cho, 2007) 	<ul style="list-style-type: none"> Identified 10 leadership characteristics more conducive to the success of LSS deployment in services sector (Laureanand Antony, 2015) Highlighted organizational leadership as an essential resource and a critical success factor of LSS (Pande, 2000; Achanga et al., 2006), 	<ul style="list-style-type: none"> Highlighted 5 key read factors for LSS deployment in Higher Education Sector (Antony, 2014a) Unstructured approach to project selection creates gap between strategy and operational portfolio (Korn and Kara, 2013) Identified generic template for defining PI projects by analyzing 181 projects across 14 financial service organizations through case based reasoning and retrospective analysis (Lokkerbol et al., 2012) Data quantity and data quality and top management support are key readiness factors (Heckl et al., 2010) Demonstrated a clustering technique to group similar processes based on seven process characteristics for project identification (Duarte et al., 2012)
<p>4. LSS tools and techniques</p>	<p style="text-align: center;">Graphical/non-statistical tools</p> <ul style="list-style-type: none"> Utilizes 'observation tool' to increase speed and eliminate waste in LSS at European airport (Arumugam et al., 2012) Proposes a coherent framework for understanding the tools and techniques of 'Voice of the Customer (VoC) in a Lean Six Sigma implementation (Found and Harrison, 2012) Critical to Quality (CTQ) flow down tree was proposed as a tool for project selection (Gates, 2007) Proposed seven standard LSS project templates based on 49 definitions (Koning, 2010) Demonstrated the application of histograms, Pareto charts, probability plots, process maps, time series plots and control charts through LSS implementation for improving claim processing for Insurance business (Sarkar, 2013) Waste analysis, Value Add-Non Value Add analysis, Value Stream mapping, 5S, Poka Yoke, Percentile Analysis, fishbone diagrams, why-why analysis, brainstorming, QFD, Box plots, scatter plots, GEMBA (George et al., 2005; Womack and Jones, 2003; Janet H Sanders, 2015; Alessandro et al., 2013; Sanjiv Ray and Bobby John, 2011; Braglia et al., 2009; Womack, 2011) <p style="text-align: center;">Quality Management philosophies and organisation practices</p> <ul style="list-style-type: none"> Lack of integration of quality management approaches leads to problems in process improvements (Mignuel and Carvalho, 2014) Integration of LSS with QM practices help organizations to gain a competitive advantage in the market (Kheradia, 2011) Implementation of Lean Six Sigma through ISO 9001:2008 (Karthi et al., 2013) Developed a comprehensive model, integrating ISO 9001:2008 Quality Management System, ISO 14001:2004 Environmental Management System, Occupational Health and Safety Management System (OHSAS 18001:2007), Six-Sigma (DMAIC methodology), knowledge management, lean thinking, and Total Quality Management (Pal Pandi et al., 2014) Integration of product optimization technique with LSS (Bessens, 2014) Integration of Supply Chain Mgt with LSS for disaster relief (Madu, 2014) Combining LSS with Balance Score Card (Kreuzer, 2011) Integrating LSS with Deming's philosophy of quality improvement (Montgomery, 2010) Proposed integration of LSS DMAIC cycle with project management standards of PMI (Teneraand Pinto, 2014) Highlights the importance of integrating organizational leadership with LSS practice (Laureanand Antony, 2015) Conceptual framework of HRM practices, strategic climate and LSS (De Koeijer et al., 2014) Highlights the importance of Lean production, six sigma quality, TQM and company culture (Dahlgard et al., 2006) 						
<p>5. Integration with other philosophies</p>	<p style="text-align: center;">Systems thinking concepts</p> <ul style="list-style-type: none"> LSS implementation requires integration of organisational practices to provide a pragmatic approach to systems (Bullas and Bryant, 2007) Developed Tandem-Lean-Value-Sigma model integrating LSS with Systems thinking theories (Kheradia, 2011) 						
	<ul style="list-style-type: none"> Proposed tools for project Developed simulation tests and t-tests, χ^2, DOE, Jayaraman et al., 2014; Montgomery and Jayaraman et al., 2012) Integration of LSS with Integration of LSS, creative 						

Figure 1 – Summary of Methodology used

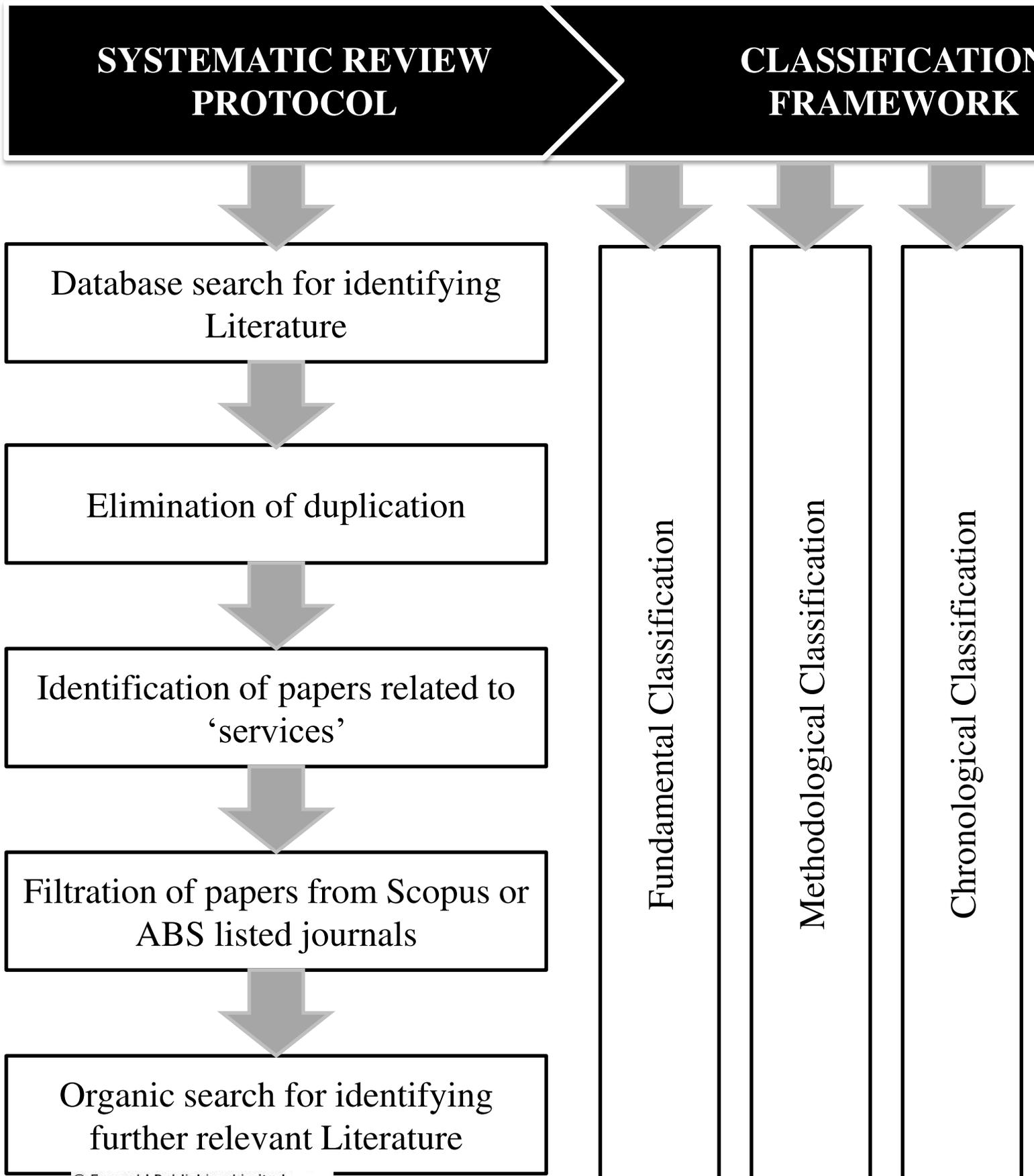


Figure 2 –
Summary
of
chronologi
cal
classificati
on

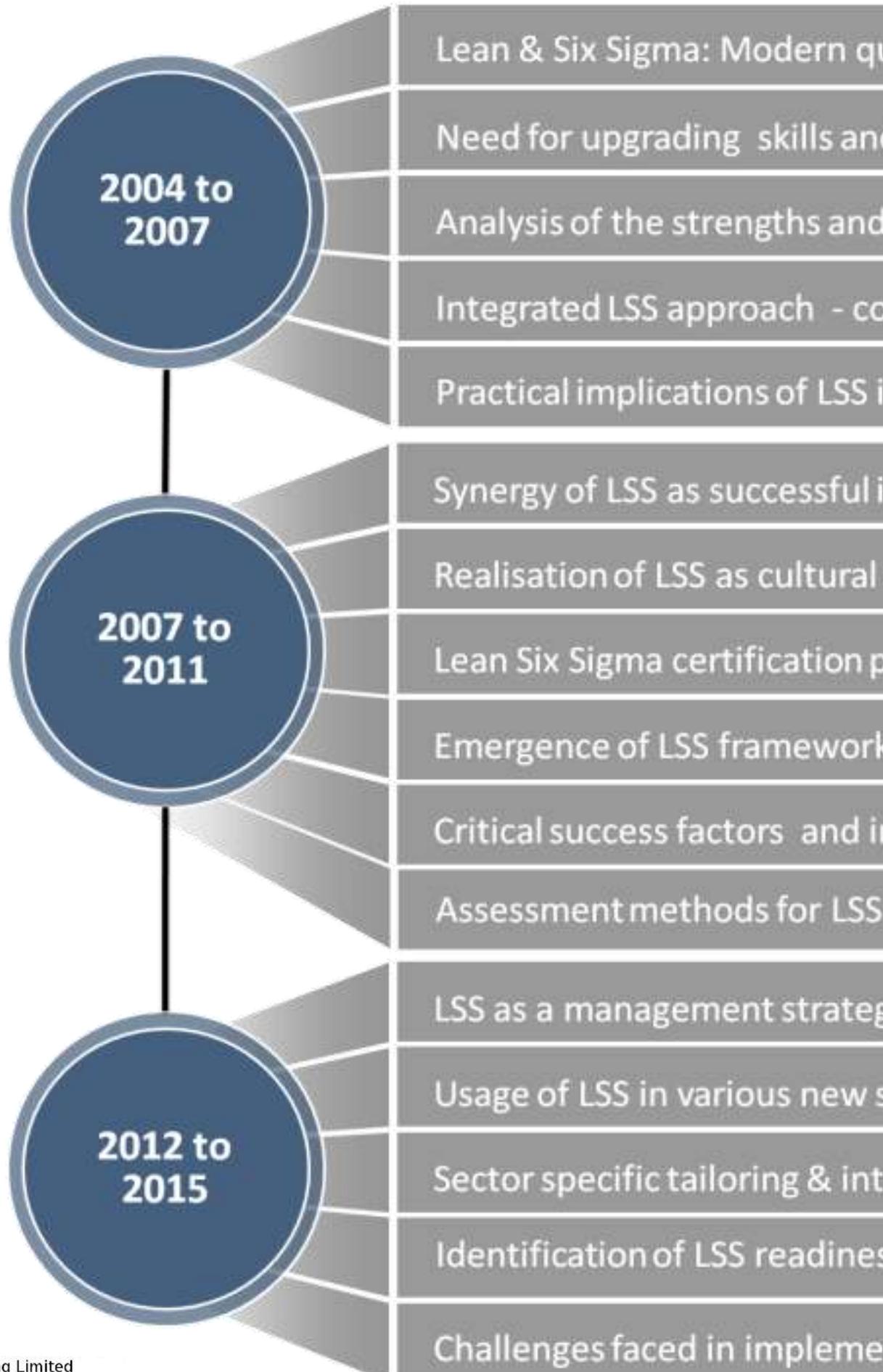


Figure 3 – Cross consistency Matrix of MA Framework

		Organizational context of application									Desired Outcomes										
		VAR1	VAR2	VAR3	VAR4	VAR5	VAR6	VAR7	VAR8	VAR9	VAR10	VAR11	VAR12	VAR13	VAR14	VAR15	VAR16	VAR17	VAR18	VAR19	
Desired Outcomes	VAR10	✓	✓	✓		✓	✓	✓		✓											
	VAR11			✓				✓													
	VAR12		✓			✓															
	VAR13	✓	✓	✓				✓	✓	✓											
	VAR14	✓	✓	✓	✓	✓	✓	✓		✓											
	VAR15		✓	✓		✓		✓		✓											
	VAR16		✓	✓				✓	✓												
	VAR17		✓	✓	✓	✓			✓	✓	✓										
	VAR18				✓																
	VAR19		✓							✓											
	VAR20					✓				✓	✓										
	VAR21			✓		✓				✓	✓										
	VAR22		✓			✓															
VAR23								✓													
Implementation systems	VAR24		✓								✓			✓	✓	✓					
	VAR25	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓	
	VAR26		✓	✓		✓					✓			✓	✓				✓		
	VAR27	✓	✓	✓	✓	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	
	VAR28		✓	✓	✓	✓		✓		✓	✓			✓	✓	✓	✓	✓			
	VAR29		✓			✓		✓			✓								✓	✓	
	VAR30		✓		✓						✓			✓				✓			
	VAR31		✓					✓			✓							✓			
	VAR32		✓			✓		✓	✓		✓	✓		✓	✓	✓		✓			
Tools & techniques	VAR33	✓	✓	✓	✓	✓	✓	✓	✓	✓		✓	✓	✓	✓						
	VAR34	✓	✓	✓	✓	✓	✓	✓	✓	✓			✓	✓	✓						
Integration with other philosophies	VAR35		✓			✓	✓	✓		✓			✓	✓	✓	✓	✓	✓	✓	✓	
	VAR36		✓							✓		✓							✓		
	VAR37		✓					✓		✓											
Evaluation methods	VAR38												✓			✓	✓				
	VAR39															✓	✓				
	VAR40		✓							✓	✓		✓	✓		✓	✓				



Research Gap



Evidence of research found in literature