

# **A Systematic Literature Review of Hybrid Approaches of Lean, Agile and Six Sigma Philosophies in Supply Chain Management**

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# DEDICATION

*I dedicate this achievement to my beloved husband Saif Ahmed  
for unparalleled love, patience, and support.*

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# **STATEMENT OF ORIGINAL AUTHORSHIP**

The work contained in this thesis has not been previously submitted to meet the requirements for an award at this or any other higher education institute. To the best of my knowledge and behalf, the thesis contains no material previously published or written by another person except where due reference is made.

Signature:

A solid black rectangular box used to redact the author's signature.

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## **LIST OF ABBREVIATIONS**

DMAIC	Define, Measure, Analyse, Improve and Control
KPI	Key Performance Indicator
LA	Lean Agile
LSS	Lean Six Sigma
LASS	Lean Agile Six Sigma
SLR	Systematic Literature Review
SRQ	Sub-Research Question
SSA	Six Sigma Agile
TLR	Traditional Literature Review

## **ABSTRACT**

The purpose of this study is to critically review the current literature on hybrid approaches of lean, agile and six sigma applications in supply chain management. Lean, agile and six sigma are improvement philosophies; these are developed in the manufacturing industry. In the last two decades, the applications of these philosophies have received considerable attention in both the manufacturing and the service industries. This attention is evident in many published studies in different journals, showing challenges and limitations for adopting these philosophies, including the integrated lean six sigma (LSS) and lean-agile (legality or leagile) in the supply chain practices. However, studies on hybrid approaches of lean, agile and six sigma philosophies in the supply chain management using a systematic literature review are relatively lacking. With this motivation, this study aims to address such gaps in the supply chain management literature. More specifically, it focuses on exploring the challenges and limitations to identify the benefits of hybrid approaches in border supply chain management. In particular, to identify how those challenges and limitations impact on overall supply chain practices and performance. To this end, the final sample of 118 peer-reviewed articles was reviewed to constitute the knowledge base of the study. Therefore, this study critically reviewed and analysed previous theoretical and evidence-based literature on the key themes associated with the topic by using a systematic literature review.

This study adopted a systematic literature review research methodology involving a three-stage review method. The three stages were (1) planning the review; (2) conducting the review; and (3) reporting and dissemination. This study presents the details of the literature search, outcomes of the search, subsequent analysis of 118 articles from 40 different journals, and contributions to knowledge, key findings and recommendations.

This study is one of the first systematic literature reviews on hybrid approaches of lean, agile and six sigma philosophies, in particular reviewing the literature to explore to what extent hybrid approaches of these philosophies influence supply chain practices and performance in the context of various industries. None of the previous literature has critically reviewed the hybrid approach of lean, agile and six sigma philosophies in terms of challenges and limitations in the context of supply chain practices.

This study adds to the existing literature by critically reviewing the literature on hybrid approaches of lean, agile, and six sigma philosophies, emphasizing challenges, limitations, and benefits of integrated approaches in the context of supply chain management for various industries. Based on a critical literature review, a conceptual framework is developed as the basis of integrated LASS philosophy for supply chain management.

**Keywords:** supply chain performance, supply chain management, hybrid approaches, lean, agile, six sigma, systematic literature review, critical literature review

**Paper type:** Literature review

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# **CHAPTER 1: INTRODUCTION**

## **1.1 Introduction**

This chapter introduces the research topic by presenting the theoretical background, research questions and key objectives. It also outlines the research scope, rationale, significance and the expected contribution of this research. Finally, this chapter outlines the organisation of the thesis.

## **1.2 Research background**

The supply chain is a network of organisations/entities connected through upstream and downstream linkages where each organisation involves different business processes and activities that produce value in the form of products and services delivered to the ultimate customer (Christopher, 2016). According to Mentzer et al. (2001), a supply chain is a set of three or more entities such as organisations or individuals, directly connected with both upstream (i.e. supply) and downstream (i.e. distribution) flows of products, services, finances and/or information from a source to end customer. It (supply chain) consists of a large number of partners such as suppliers, manufacturers, wholesalers, distributors, retailers and customers. Figure 1 shows a typical supply chain network of multiple businesses and relationships. It shows how multiple supply chain partners are connected for effective and efficient flows in a supply chain network (Lambert et al., 1998). Furthermore, the supply chain could be considered as a key driver of business connectivity, connecting all partners involved in the network.

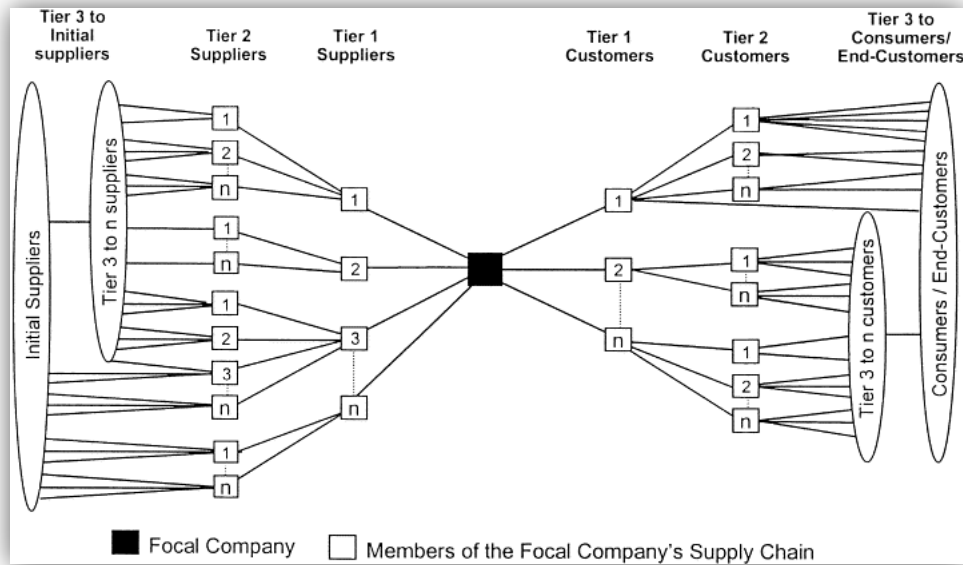


Figure 1: Supply chain network structure

Reproduced from Lambert et al. (1998)

The concept of supply chain management refers to the practice of managing the business connectivity of the flow of products/services and information across the entire supply chain (from the supply of raw materials, manufacturing of products and distribution of products to the end customer) (Lambert and Cooper, 2000). With the increasing popularity of the term supply chain management, both in academia and practice, there is considerable confusion as to its appropriate definition (Mentzer et al., 2001). Cooper et al. (1997) define supply chain management as “an integrative philosophy to manage the total flow of a distribution channel from supplier to the ultimate user.” Regarding operational terms involving the flow of materials and products, some argue supply chain management is a management philosophy while some argue it is a type of management process (Lambert and Cooper, 2000, Cooper et al., 1997, Ho et al., 2002, Mentzer et al., 2001). Supply chain management consists of three closely related elements. These elements are as follows:



- i. The supply chain network structure that comprises of the member firms and links between those firms,
- ii. The supply chain business processes of cross-functional processes including procurement, production, warehouse, sales and marketing, finance, research and development and human resource, and
- iii. The supply chain management components such as the integration of key business processes and functions within and across the supply chain, are structured and managed.

Furthermore, supply chain management is the enabler of coordinating and integrating key business processes for providing goods and services that add value for customers and other stakeholders (Lambert et al., 1998). Fundamentally, the main focus of this coordination and integration among activities across the supply chains is to achieve a desired level of performance, thereby achieving a competitive advantage in the supply chain (Lambert et al., 1998, Gunasekaran et al., 2004). To achieve the desired level of performance in the supply chain, managers are increasingly adopting necessary technology/techniques in purchasing, procurement, and other supply chain activities (Thomas and Griffin, 1996, Laosirihongthong et al., 2019, Gunasekaran et al., 2004). The widely applied tools and techniques are just in time (JIT), total quality management (TQM), lean production, six sigma, agile, including integrated lean six sigma (LSS) and lean agile (Leagility) among others (Al Owad et al., 2018a). However, in the current global business environment, managing supply chain practices for improving performance across the network is a challenging task.

The importance of supply chain performance improvement is receiving increased attention from various industry perspectives (Taieb and Affes, 2013, Shepherd and Günter, 2010). Effective and efficient supply chain performance has become an essential requirement for a supply chain to achieve a competitive advantage in the business (Cai et al., 2009, Trkman et al., 2010). In order to develop a performance measurement system and metric, it is vital to

consider the effectiveness and efficiency measures of the supply chain. In a seminal paper, Neely et al. (1995) defined that a performance measurement system is a “set of metrics used to quantify the efficiency and effectiveness of actions.” A metric is a piece of information with three distinctive features: (i) it is a verifiable quantitative or qualitative performance measure, that assesses what is happening; (ii) it is assessed through a reference or target value; and (iii) it is associated with consequences of being on or below or above target (Maestrini et al., 2017).

In order to achieve desirable performance in the supply chain, many authors emphasise the need for performance measurement in the strategic, operational, and tactical levels of the supply chain (Arzu Akyuz and Erman Erkan, 2010, Gunasekaran et al., 2004, Maestrini et al., 2017). For example, Gunasekaran et al. (2004) developed a framework for supply chain performance measurement in the context of supply chain activities/processes. Such supply chain activities and processes are: (1) plan, (2) source, (3) make/assemble, and (4) delivery/customer. They have shown the metrics for order planning require three important measures, such as order planning method, order lead-time and the customer order path (Gunasekaran et al., 2004). They indicate how customer satisfaction is converted into information exchanges through the supply chain. Gunasekaran and Kobu (2007) argue that performance measurement in the supply chain is vital and mentions eight important purposes for a performance measurement system. In the new supply chain era, performance measurement is a relatively open area for research (Arzu Akyuz and Erman Erkan, 2010, Maestrini et al., 2017). However, performance improvement in the supply chain is a challenging task due to the complex nature of the supply chain (Gawankar et al., 2016).

Major supply chain complexities are multiple supply chain entities, large numbers of stakeholders, dimensions of the network structure and the involvement of various processes at

both organisational and supply chain levels. In addition to that, numerous events influence supply chain operations, which impacts on overall supply chain performance (Samaranayake et al., 2016). Some of these events include natural disasters, terrorist attacks, volatile market conditions, technological innovation, and globalisation. These events are creating many problems and uncertainty in the supply chain. Thus, complexity and uncertainty associated with supply chain practices could influence overall supply chain performance. In relation to improving performance and thereby achieving a competitive advantage in such environments, there is a need to have appropriate improvement philosophy in the supply chain (Adebanjo et al., 2016c). Dhallin (2011) stated that 75% of organisations are currently employing various improvement philosophies to achieve effective and efficient performance in the supply chain. It is evident from the literature that lean, agile, and six sigma are widely adopted improvement philosophies in supply chain practices (Mishra and Sharma, 2014, Jasti and Kodali, 2015, Foster Jr, 2007).

Zhou (2016b) applied lean improvement philosophies in small and medium-sized enterprises, with a particular focus on improving quality and services, eliminate wastes, reduce time and cost and enhance operational performance in the supply chain. With the significant success of the lean philosophy, it has become a popular business model in the global supply chain (Mason and Evans, 2015, Singh and Pandey, 2015a). Gligor et al. (2015) argue that the agile supply chain has the opportunity to increase speed and flexibility through supply chain practices. From a six sigma perspective, the application of six sigma in the supply chain emphasises identifying and eliminating defects or variations in the supply chain practice. The successful deployment of six sigma enables quality improvement in supply chain practices (Antony, 2011b). The main focus of lean, agile and six sigma philosophies is to deploying continuous improvement in supply chain practices.

In recent years, Lean and Six Sigma (LSS) have become the widely applicable business philosophies for deploying continuous improvement (CI) for various industry sectors such as manufacturing and service sectors, as well as in the public sector (Albliwi et al., 2015). In the supply chain practices, the integrated lean six sigma (LSS) works as a dominant improvement philosophy (Drohomeretski et al., 2014). In addition, the integrated lean agility as an improvement philosophy that could have the potential to influence supply chain performance (Mostafa et al., 2016, Nakandala and Lau, 2018).

Given the importance of supply chain performance, some authors suggest that integration of two approaches could lead to improve quality, reduced costs and improve delivery times in supply chain practice (Ambe, 2014, Cai et al., 2009). When the application of lean philosophy is in isolation, it is unable to minimise variations in the supply chain practices (Drohomeretski et al., 2014). Similarly, the application of six sigma in isolation has sometimes been unable to reduce wastes in the supply chain, leading to the idea that the integration of the two approaches can achieve a better result than either approach could achieve alone (Antony, 2011b). However, some others suggest that a systematic approach to redesigning business operations relatively could be the better option (Godsell et al., 2010). Others argue that a combination of two or more improvement approaches, namely, a hybrid approach could be a better option (Mishra and Sharma, 2014, Christopher and Towill, 2001b). Hybrid means the combination of two or more distinct components working together for a better result.

Increased interest in hybrid approaches of lean six sigma (LSS), leagile or legality in various industries of supply chain practices is evident from a range of studies (Naylor et al., 1999, Yusuf et al., 2004b, Arnheiter and Maleyeff, 2005, Hilton and Sohal, 2012a, Antony and Kumar, 2012b, Paul Martin et al., 2012, Nakandala and Lau, 2019). For example, Arnheiter and Maleyeff (2005) emphasised on the application of LSS improvement into a

comprehensive management system. In this case, the application of LSS in the comprehensive management system leads to increases in the level of quality of the products and the reliability of processes in the supply chain. Snee (2010) introduces LSS as a business strategy and methodology. The adoption of LSS in the supply chain practices has influenced maximising sustainable process improvement and consequently improving the satisfaction of the ultimate customer in the supply chain. Similarly, Drohomieretski et al. (2014) indicate that LSS as an operations management model that contributes to continuous improvement in supply chain practices. Furthermore, continuous improvement leads to achieving superior performance in supply chain management.

Although LSS is one of the best hybrid improvement philosophies that many organisations have adopted in their supply chain practices (Laureani et al., 2010, Li et al., 2009), research into current practices using hybrid approaches is relatively in early stages (Albliwi et al., 2015, Laureani et al., 2010, Albliwi et al., 2014b). Using a literature review, Albliwi et al. (2014b) identified 34 critical failure factors of LSS in the context of manufacturing, services, and the higher education sector. Among them, highly noticeable factors include lack of top management commitment and involvement, lack of communication, lack of training and education, and limited resources. Shokri (2017a), based on the analysis of current research studies relating to integrated LSS indicated that current practices focus on relatively limited areas such as limited manufacturing and services industries in the supply chain.

In a case study research, Nakandala and Lau (2018) adopted an innovative hybrid approach of leagility (a mix of lean and agility approaches) in respect to mitigating demand uncertainty in the fresh food supply chain, where high responsiveness is needed. The authors indicate that there is a need for empirical research on leagility, specifically for the agri-food supply chain sector. Furthermore, there is a lack of empirical research and a lack of data collection

opportunities in the field of research into lean agility in the supply chain practices (Albliwi et al., 2014b, Shokri, 2017a). The evidence of the relationship between these philosophies (lean, agile, and six sigma) and supply chain performance has proved inconclusive.

The majority of the published research on LSS or lean agility focuses on developing operational strategies/models for the supply chain. However, they are unable to arrive at the point of integrating lean, agile, and six sigma (LASS) for a broader supply chain management. Although a wide range of studies on lean, agile and six sigma philosophies have been reported over the last two decades, these philosophies are working better in isolation deployment in the supply chain practices. However, a hybrid approach of LASS for supply chain practices is yet to receive attention (Drohomeretski et al., 2014, Mishra and Sharma, 2014, Jasti and Kodali, 2015). Therefore, this study aims to critically review and analyse theoretical and evidence-based literature related to the theme of the topic to explore challenges and limitations of hybrid approach of LASS and to identify benefits of the LASS approach in complex supply chain practices.

### **1.3 Problem statement**

Due to the complex nature of the supply chain, managing supply chain practices are challenging (Gawankar et al., 2016). Along with such complexity, volatile market conditions, technological innovation, globalisation, natural disasters, pandemic (COVID -19) and terrorist attacks are creating many problems in the global supply chain. To overcome such problems, there is a need to have better improvement philosophies in supply chain practices. Therefore, addressing the research gap in the literature outlined above with other considerations promotes the following central research question.

## **1.4 Research questions**

**To what extent the current integrated approach of lean, agile and six sigma influence supply chain practices and performances?**

The central research question is broken down into following sub-research questions (SRQs):

**SRQ1:** What are the models and/or strategies adopted in hybrid approaches of lean, agile, and six sigma and how do these approaches influence supply chain performance?

**SRQ 2:** What are the challenges and limitations that are present in current hybrid practices and how these approaches influence supply chain practices and performance?

**SRQ 3:** What are the possible benefits of LSSA applications in supply chain practices and performance?

## **1.5 Research objectives**

Based on the research questions, the study has the following objectives:

- To understand the current hybrid approaches of lean, agile, and six sigma from the perspectives of models and strategies being adopted in various industries (manufacturing, services, automotive services, healthcare services, and the educational sector including the agri-food supply chain sector) of supply chain and how these approaches influence supply chain performance.
- To identify the challenges and limitations of hybrid approaches in current supply chain practices across a range of industries.

- To identify potential benefits of the LASS hybrid approach in supply chain management.

## **1.6 Scope of the research**

The main scope of the research is the contemporary literature related to hybrid approaches of lean, agile, and six sigma in the context of supply chain management across various industries (manufacturing, services, automotive services, healthcare services, and the educational sector including the agri-food supply chain sector).

## **1.7 Rationale for the research**

A preliminary examination of the literature identified the broader application of lean six sigma (LSS) or lean agile (LA) in the supply chain practices. It is noted that there is significant published research studies relating to LSS or LA philosophies in the supply chain practices (Sreedharan and Raju, 2016, Naylor et al., 1999, Drohomeretski et al., 2014, Antony et al., 2012, Nakandala and Lau, 2019). Snee (2010) has developed a framework that identified the essential themes of LSS integration for various levels of supply chain practices. Both lean and six sigma works as a powerful improvement philosophy; thereby, the integrated application of LSS offers potential improvement in supply chain practices and improve performance (Antony and Kumar, 2012b).

Although lean and six sigma philosophies have disparate roots, both lean and sigma philosophies are encompassing many common features in the supply chain practices (Antony and Kumar, 2012b). These common features are comprehensive employee involvement, emphasis on customer satisfaction, a culture of continuous improvement, and search for root causes. Antony et al. (2016) focus on the comprehensive analysis of LSS. They indicate that lean six sigma is likely to have a significant influence on process/product/service performance



in the supply chain. They identified that the integration of LSS enhances customer satisfaction by accelerating the bottom-line results in the agile supply chain.

In a case study research, Naylor et al. (1999) have shown a successful integration of agility and leanness within the PC manufacturing supply chain. They indicate the similarities and differences between lean and agile paradigms. Fundamentally, the agility paradigm is different from the lean paradigm (Naylor et al., 1999). The agility paradigm is best suited to satisfying fluctuating demand, and lean paradigm requires a level of scheduling (Gligor et al., 2015, Naylor et al., 1999) in the supply chain practices. Christopher (2000) demonstrates a deeper understanding of supply chain agility by introducing an integrated approach of lean agility in the supply chain practices.

Studies indicate the integrated LSS or lean agile has been widely adopted by several manufacturing and service organisations in the supply chain practices (Christopher, 2000, Gunasekaran, 1999, Naylor et al., 1999). However, there are relatively limited studies exist relating to LSS or lean agile application in the context of broader supply chain management. Some researchers argue that top management support or training related to LSS or lean agile in the supply chain are also sketchy (Eckstein et al., 2015, Gligor et al., 2015, Yusuf et al., 2004a). More importantly, research related to lean agile integration in the supply chain relatively limited. However, the integrated approach of lean agile has a potential influence on supply chain practices (Christopher, 2016, Naylor et al., 1999). There is a need for research on the integrated leagile approach in the supply chain (Gligor et al., 2015, Swafford et al., 2006).

Although integrated LSS and LA approaches have attracted increasing attention from practitioners and academia (Antony et al., 2012, Nakandala and Lau, 2019, Shokri, 2017b, Cheng and Chang, 2012, Christopher, 2000), there is relatively little attention paid on hybrid

approach of SSA, particularly integration and challenges in the context of supply chain management. While LSS and LA have been well researched in the context of supply chain practices (Snee, 2010, Naylor et al., 1999, Albliwi et al., 2014b), the hybrid approach of LASS has received relatively less attention. Furthermore, these studies have not thoroughly and/or critically reviewed these approaches in the context of supply chain management by using a systematic literature review. More specifically, there is relatively limited research into the investigation into limitations and challenges from the perspective of the level of integration in the supply chain, taking down-stream and up-stream supply chain, industry and global nature of supply chain into consideration and to identify possible benefits in the supply chain practices. Considering this lack of research studies in the literature, this study aims to explore challenges and limitations from the perspective of the level of integration in the supply chain, taking down-stream and up-stream supply chain, industry and global nature of supply chain and to identify possible benefits of such philosophies in supply chain management.

## **1.8 Significance of the research**

Organisations currently face constant change in the external environment, driven by heightened competition, more demanding consumers and relatively unstable economic climates in many countries (Nahm et al., 2006, Karim et al., 2008, Drohomieretski et al., 2014). Running operations at the lowest cost, with higher reliability and speed and superior ability to change and continuously improve, are some of the norms in the development of operations strategy in organisations that seek to survive in a competitive environment (Hayes and Pisano, 1996, Priya Datta and Roy, 2011, Voss, 2005, Ward and Duray, 2000).

Although the importance of performance improvement in the supply chain is emphasised in many research studies (Arzu Akyuz and Erman Erkan, 2010, Gunasekaran and Kobu, 2007,

Gunasekaran et al., 2004, Maestrini et al., 2017), however, research studies on integrated LASS improvement approach for the supply chain performance are relatively lacking. In addition, Zimmermann et al. (2016) argue that there have been relatively little systematic literature review studies related to performance improvement for the supply chain perspective and emphasised the need for further research. Given the importance of performance improvement in the supply chain context, the application of hybrid improvement approaches such as lean six sigma may achieve better results than individual systems can achieve alone (Dhallin, 2011, Drohomieretski et al., 2014, Antony, 2011b). In this context, it was found that agility and supply chain adaptability positively affect both cost performance and operational performance perspectives (Eckstein et al., 2015). In order to validate and expand the theoretical framework for supply chain agility, further research is needed, as agility has a significant impact on supply chain performance (Eckstein et al., 2015).

Although the importance of supply chain performance improvement has been studied for decades (Gunasekaran et al., 2004, Al Owad et al., 2014), relatively little importance has been paid on hybrid approach of LASS for improving the supply chain performance (Tranfield et al., 2003, Zimmermann et al., 2016). Studies on hybrid approaches of lean, agile and six sigma philosophies in the supply chain management literature are relatively lacking, in particular studies on the hybrid approach of LASS, taking inter-dependencies influenced by the order/sequence of the implementation into consideration. To the best of research knowledge, the dearth of systematic literature review relating to hybrid approaches of lean, agile, and six sigma philosophies in the context of supply chain management literature (S. Reosekar and D. Pohekar, 2014).

The significance of this study is offering a critical literature review of challenges, limitations and benefits of hybrid approaches of lean, agile and six sigma from the perspective of the

level of integration in the supply chain, taking down-stream and up-stream supply chain, industry and global nature of supply chain into consideration using a systematic literature review methodology. The claim of a critical literature review on hybrid approaches of lean, agile, and six sigma philosophies in the context of supply chain management is relatively new compared to previous studies (Chakravorty and Shah, 2012, Derwik and Hellström, 2017 (Snee, 2010, Soni and Kodali, 2012). Adding to that, most of the previous studies have limited to the investigation of two integrated approaches, such as lean six sigma (LSS) or lean agile (Legility/leagile) in the context of SCM. This study identified very limited research studies into the integration of three improvement philosophies (lean, six sigma and agility) in supply chain context across a few industries (e.g. manufacturing, services, automotive services, healthcare services, and the educational sector including the agri-food supply chain sector). This study explores integrated approaches of three improvement philosophies of lean, agile and six sigma in the context of supply chain management.

## **1.9 Contributions to knowledge.**

This study adds to the existing literature by critically reviewing the current literature on hybrid approaches of lean, agile and six sigma philosophies, emphasising challenges, limitations and benefits of integrated approaches in the context of supply chain management for various industries. This research also provides a deeper understanding of the nature of the challenges to combine lean and agile throughout one supply chain process or practice. From this end, this study identified integrated LA and LSS philosophies that can be work together in the different portions (upstream and downstream) of one supply chain. This study also explores challenges, opportunities and limitations of integrated LA and LSS adoption in the supply chain and identified possible benefits such as cost reduction, saving time and improve quality in supply chain practices. Based on a critical literature review, this study developed a

conceptual framework, which is the basis of integrating LASS philosophy in supply chain management.

## **1.10 Thesis organisation**

This thesis is organised into six chapters. Chapter 1 introduces the key theme associated with the broader research topic, describes the background of this research topic and explains the rationale as well as the significance of this research. Also, it introduces the scope and the primary aim of this study. It then outlines the research objectives, research questions and expected contributions of this study. Chapter 2 provides a critical literature review on current hybrid approaches of lean, agile, and six sigma philosophies in the supply chain for various industries. It outlines the limitations and challenges of hybrid approaches and summarises existing literature in the context of supply chain management. It also outlines the integrated LSS, Lagile and LASS for the supply chain management. Chapter 3 describes the research methodology, which includes the three-stage method adopted for carrying out the systematic literature review:

1. Planning the review
2. Conducting the review
3. Documenting the review

Chapter 4 provides an analysis of the critical literature review for this study. Chapter 5 then describes the key findings and provides a discussion of these findings for the study. Finally, it presents the conclusions and future research directions of this study present in Chapter 6.

## **CHAPTER 2: LITERATURE REVIEW**

### **2.1 Introduction**

The previous chapter outlined the underlying research background and the research plan of this study. This chapter critically reviews the literature on lean, agile and six sigma, including integrated LA and LSS application in supply chain practices of various industries. The critical literature review provides an insight into the literary contribution of integrating individual approaches of lean, agile and six sigma philosophies in the context of supply chain management. It presents limitations and challenges of integrating lean, agile and six sigma philosophies in supply chain practices. It also presents a comparison between these philosophies by integrating lean agile (Leagile) and lean six sigma (LSS) in the supply chain practices. Finally, it presents a conceptual framework of LASS for supply chain management as the basis for the evaluation of a hybrid philosophy.

### **2.2 Lean philosophy in the supply chain**

In the 1950s, lean philosophy originated in the Toyota Production System and was adopted in other manufacturing industries. It is often perceived as a set of tools and techniques (Womack et al., 1990). These views are widely introduced to the world in the famous book '*The Machine That Changed the World*' (Womack and Jones, 1994). Lean philosophy is also known as lean production, lean manufacturing, lean thinking, lean supply chain management (Womack and Jones, 1994, Womack and Jones, 1996, Myerson, 2012). The focus of lean means is about doing more with less in the supply chain practices (Singh and Pandey, 2015b)

One of the focus of lean philosophy is the elimination of wastes or non-value added activities in supply chain practices as a result reduce cost in the supply chain practices (Arif-Uz-Zaman and Nazmul Ahsan, 2014). The non-value added activities or seven types of wastes in the supply chain practices are over-production, defects, waiting time, excessive transportation, inappropriate processing, unnecessary inventory and unnecessary motion (Demeter and Matyusz, 2011, Al Owad et al., 2018b). These seven types of wastes do not directly contribute to adding value to the supply chain processes from a customer point of view (Zhou, 2016b, Pheng, 2016). Furthermore, the core principle of the lean supply chain is to create effective and efficient process flow that adds value to the supply chain. The main focus of these value creation activities is to meet customer demand by reducing or removing all kinds of wastes in the supply chain (Myerson, 2012). According to Womack and Jones (1994), the lean supply chain is guiding by the following lean principles:

1. Specify a value from the standpoint of the end customer;
2. Map the value stream;
3. Achieve flow through the process;
4. Establish pull production; and
5. Seek perfection.

The application of lean principles in the supply chain practices enables to create a competitive advantage. The extent of lean philosophy is becoming a popular business model in many industries around the globe (Al Owad et al., 2018a). Over the last two decades, lean philosophy has become an integral part of manufacturing industries in the US as well as in many countries around the world (Chun Wu, 2003, Furlan et al., 2011). Lean manufacturing encompasses many improvement philosophies, such as continuous improvement (CI), just-in-time (JIT), total quality management (TQM), among others (Karlsson and Åhlström, 1996).

Furlan et al. (2011) have shown the combination of JIT and TQM complement each other for improving human resources management in the supply chain.

Similarly, as a business model, lean philosophy extended to health care services, education, bank, including public services organisations (Ugochukwu et al., 2012, Antony et al., 2017, Adebajo et al., 2016a). For example, Adebajo et al. (2016a) extended comprehensive literature on lean supply chain management (LSCM) in the context of the health care service.

In order to improve performance in the healthcare sector, they prioritise the drivers and resources required to implement lean supply chain management. Lean philosophy is increasingly being adopted/used across a wide variety of healthcare settings, specifically for improving performance in operations in the context of the health care supply chain (Adebajo et al., 2016b, Al Owad et al., 2018a). The successful application of lean philosophy in the healthcare sector could improve the physical flow of material in hospitals, reduce waiting times, as a result, increase patient satisfaction (Matthias, 2016, McFadden et al., 2015).

Research indicates there is no single way of implementing lean in the healthcare supply chain, as it is challenging to adopt an idea from one lean culture and then apply it to other lean cultures (Antony and Kumar, 2012a). For example, the effective lean application in large organisation relatively less compatible with small and medium-sized enterprises (SMEs) (Bhasin, 2011).

In recent times, small and medium-sized organisations are widely adopting lean philosophy as a business model for improving their efficiency and competitiveness in their supply chain practices (Zhou, 2016b). The significance of lean adoption has witnessed in SMEs, as many SMEs have become important competitors in the supply chain network. However, lean philosophy is more successful in a large organisation than a small and medium-sized organisation (Bhasin, 2011). For instance, the models/frameworks that are developed for large



organisations, there is a need for customizing these models/frameworks for SMEs to adopt lean philosophy (Kumar et al., 2011a).

In order to remain competitive in the supply chain, a significant number of businesses around the globe are adopting lean improvement philosophy in their supply chain practices (Adebanjo et al., 2016b, Arif-Uz-Zaman and Nazmul Ahsan, 2014). The application of lean philosophy in the supply chain creates a smooth process flow that helps to meet customer requirements in the supply chain (Zhou, 2016b). For example, Tesco, the UK's food retailer, has become a world-class retail industry level, which is the consequence of the successful application of lean philosophy in its supply chain practices (Mason and Evans, 2015, Myerson, 2012). However, lean philosophy in supply chain practices is facing many limitations.

The adoption of lean philosophy in supply chain practices has many limitations. Among them, limited management support, limited data collection opportunities, limited communication between senior management and employee, these are important limitations. These limitations are identified as significant barriers/issues in current supply chain practices (Zhou, 2016b). Furthermore, management offers limited training opportunities to educate employees relating to lean supply chain management (Myerson, 2012). From this end, lack of management support, relatively limited opportunity to empower workers, limited opportunity for resources, set time restrictions are noticeable barriers. These barriers are the leading cause of failure of lean initiative in many manufacturing and services industries in many countries (Myerson, 2012, Vamsi Krishna Jasti and Kodali, 2014). In order to adopt a lean philosophy in supply chain practices, these limitations are creating many challenges.

Lean adoption in the supply chain involved many challenges. The fundamental shift of stakeholders thinking from source to end customer (Albliwi et al., 2015) is one of the

significant challenges in the supply chain. In an organisation like the food processing industry, Ainul Azyan et al. (2017), highlights the following challenges related to the implementation of lean philosophy:

1. The challenges of a good understanding of lean principles and deciding which lean tool is appropriate for supply chain,
2. The challenges of systematic implementation of the selected lean tools through a change management/supply chain process,
3. The challenges of changing organizational culture especially, when the organisation does not understand what lean can do, and
4. The challenge of employee resistance.

Chugani et al. (2017) have shown that the application of lean philosophy in the supply chain remains in its early stages. From the perspective of the lean supply chain, Jasti and Kodali (2015) have shown, the lack of proper literature reviews on existing theories relating to the lean supply chain indicates the majority of the frameworks were developed without proper reviews of the literature. In the current competitive environment, they identified the participation of practitioner gap and recommended for further research.

In the current level of competition, technological advancement and increased customer requirements have forced many companies to continuously reshape and optimize their business operations at strategic and tactical levels (Alves and Alves, 2015, Antony et al., 2017). In order to optimize business activities, the application of supply chain management (SCM) allows more space to adopt lean in sourcing, procurement, production, and logistics management (Alves and Alves, 2015). For instance, many organisations including healthcare, education, airline, banking and finance, legal services and information technology, are

increasingly adopting lean improvement philosophy in their agile supply chain practices (Moyano-Fuentes and Sacristán-Díaz, 2012, Suárez-Barraza et al., 2012).

### **2.3 Agile philosophy in the supply chain**

The agility concept originated in the manufacturing industry. In the early 1990s, this concept was popularized by a group of scholars at the Iaccoca Institute of Lehigh University (Nagel and Dove, 1991). Subsequently, the agility concept has experienced increasing attention in many industry sectors, including production and supply chain management research (Goldman et al., 1995, Gunasekaran, 1999, Naylor et al., 1999, Yusuf et al., 1999). According to Naylor et al. (1999), “agility means using market knowledge and virtual corporations to exploit profitable opportunities in a volatile marketplace.” Christopher (2000) suggests that agility is “a business-wide capability that embraces organisational structure, information system and in particular, minds sets.” The key characteristic of agility is a quick response to the changing environment in the supply chain practices in order to respond to a rapid change in demand, both regarding volume and variety (Christopher, 2000, Li et al., 2009, Lau and Hurley, 2001). The key driver for responding to these changes are inherent in time-based competition, and it is recognised as one of the powerful sources of competitive advantage (Stalk, 1988) in the agile supply chain. From this perspective, supply chain agility is characterized by dynamic capabilities that positively influence the operational efficiency in the supply chain practices (Gligor et al., 2015). In order to emphasise a broader aspect of supply chain agility, it (agility) is compared with lean philosophy. According to Naylor et al. (1999), the distinguishing features of leanness and agility emphasise in the following two definitions:

**Agility** means using market knowledge and a virtual corporation to exploit profitable opportunities in a volatile marketplace.

**Leanness** means developing a value stream to eliminate all waste, including time, and to ensure a level schedule.

Naylor et al. (1999) proposed a hybrid approach of leagility (the integration of lean and agility), and they indicate a key difference between lean and agile manufacturing. The key differences are (1) agile manufacturing is best suited to satisfying fluctuating demand (in terms of volume and variety); and (2) lean manufacturing requires level scheduling. From this perspective, agility and lean philosophies are closely related to the total supply chain strategy (Naylor et al., 1999), where lean and agile paradigm carefully combine together, namely leagility.

Slack et al. (2010) have shown agility is a combination of all five operational performance metrics such as quality, dependability, speed, flexibility and cost. From this end, supply chain agility is closely related to both speed and flexibility. The idea of flexibility refers to manufacturing flexibility, which extends to supply chain management. However, agility and cost-efficiency are related to customer effectiveness, which can justify the financial performance in the supply chain (Gligor et al., 2015). Furthermore, the agility concept is multidimensional and covers broader aspects of the supply chain. Christopher (2000) indicated some characteristics that supply chains must have to be “truly agile”:

- **Market sensitive:** it is closely related to the end-user trend.
- **Virtual:** it relies on shared information across all supply chain partners.
- **Network-based:** it gains flexibility by using the strengths of specialist players.
- **Process integration:** it has a high degree of process interconnectivity between network members.

Agility is an essential factor in contemporary supply chain management. Agility directly affects operational efficiency in supply chain practices (Christopher, 2000, Naylor et al., 1999). Some research has identified the different dimensions of agility and examined many aspects from various points of the supply chain practices (Beck, 2012, Naylor et al., 1999, Gligor and Holcomb, 2012). For example, in a systematic literature review, Gligor and Holcomb (2012) introduced the role of logistics capabilities in achieving supply chain agility. They claim that supply chain agility increases speed and flexibility through the entire supply chain processes, which requires process integration and strategic alertness in the supply chain (Gligor and Holcomb, 2012). Botta-Genoulaz (2013) argued that strategic alertness is vital to develop an agility scale for supply chain practices. Strategic alertness helps supply chain actors to take the initiative to respond on specific action against individual change from the strategic level of organisations, where firms require restructuring their supply chain at the strategic level of organisation (Eckstein et al., 2015). Agility has significant importance in supply chain practices, where more research is essential (Fayezi et al., 2015). There are scalability limitations in the existing research. In some stage, the scalability limitations make it challenging to develop agility metrics for the supply chain practices (Beck, 2012, Li et al., 2009). Furthermore, until now, there are relatively few integrated frameworks indicates on six sigma agility in the context of supply chain management literature (Eckstein et al., 2015, Christopher, 2000, Naylor et al., 1999).

## **2.4 Six Sigma philosophy in the supply chain**

Six sigma is a systematic, highly disciplined, customer-centric and profit-driven organisation-wide strategic supply chain improvement initiative that is based on a rigorous process focused and data-driven methodology (Tang et al., 2007). Six-sigma, total quality management (TQM), lean, and agile philosophies are the strategic notion of various improvement

initiatives in current supply chain practices (Adebanjo et al., 2016c). In this context, continuous improvement (CI) is a norm and it (CI) has become a significant element for organisations to stay competitive in the current supply chain environment. Among various improvement philosophies, six sigma is one of the most recognized and well-established continuous improvement philosophies that are applying in the supply chain practices (Adebanjo et al., 2016c, Moosa and Sajid, 2010).

In the mid-1980s, six sigma philosophy originated in the manufacturing industry. Subsequently, this philosophy is extended to services industries, automotive services, healthcare services, financial services, educational sector, agri-food sectors, including the broader area of the supply chain (S. Reosekar and D. Pohekar, 2014, Erbiyik and Saru, 2015, Kumar et al., 2011b, Nauhria et al., 2009). The application of six sigma ensures to minimize or remove variations in the supply chain processes. A primary purpose of minimizing or removing such variations in the supply chain processes is to improve processes flow for broader supply chain management, consequently improve processes quality and increase customer satisfaction (Kumar et al., 2011b, Kuvvetli et al., 2016, Moosa and Sajid, 2010). Six Sigma implementation in the supply chain practices eliminates variation, reduces cycle time, increases customer satisfaction, creates new metrics, thereby promoting a competitive advantage in the supply chain (Jones et al., 2010). In this context, effective process control tools are applied in supply chain practices. More useful process control tools are cause-and-effect diagrams, process mapping, check sheets, histograms, control charts among others (Erbiyik and Saru, 2015).

A popular framework for implementing Six Sigma methodology in the supply chain is DMAIC (Define, Measure, Analyse, Improve and Control). In a case study, Erbiyik and Saru (2015) demonstrate a six sigma DMAIC methodology to analyses complex problems in the

supply chain for an Automotive Industry. The complex problems that they mainly look at are 1) the cause of customer complaints and 2) the suppliers originated defect. In order to evaluate the cause of customer complaints, they used the fishbone diagram and identified the root cause of customer complaints about the Automotive supply chain (Erbiyik and Saru, 2015). Such root causes are identified by analysing existing processes and the new processes in their supply chain activities. To this end, six sigma application in the supply chain activities introduces two principal improvement methodologies: such methodologies are the existing processes and the new processes (project) (Andersson et al., 2006).

Although Motorola pioneered the six sigma improvement philosophy, it was popularised by General Electric (Andersson et al., 2006, Jenica et al., 2010, S. Reosekar and D. Pohekar, 2014). Many companies, such as Texas Instruments, Honeywell, American Express, and Johanson & Johnson, have implemented six sigma in their supply chain practices (Karthi et al., 2012). In an empirical study, Antony and Desai (2009) have shown six sigma implementation in the context of an Indian manufacturing and services industry, where considerable progress has been made in such areas of the supply chain practices (Cheng and Chang, 2012, Antony and Desai, 2009).

The potential importance of six sigma adoption within the broader supply chain could significantly impact on financial and operational performance (Adebanjo et al., 2016c). The successful application of this philosophy in organisations helps to develop a culture in terms of quality, including employee empowerment, teamwork, customer focus, open communication, innovation, and overall organisational loyalty (Jenica et al., 2010). Karthi et al. (2012) have shown six sigma applications in the supply chain, but this research was limited to six sigma and a few classification criteria only. Kumar et al. (2011a) have

developed a six sigma framework for SMEs, which is based on a critical analysis of existing TQM philosophy.

Evidence from the literature indicates that the application of six sigma in the supply chain is three decades of history (Kumar et al., 2011b). However, there is relatively limited research exists relating to applications of six sigma in broader supply chain management. Evidence shows many attempts are addressing six sigma project selection using the analytical method in the supply chain practices (Antony and Desai, 2009, Cheng and Chang, 2012, Jenica et al., 2010). Implementing six sigma analytical method in the supply chain requires strong top management support, organizations, infrastructure, training, and statistical tools (Kumar and Antony, 2008). Studies indicate a lack of top management support is one of the significant challenges for implementing six sigma in the supply chain practices (Jones et al., 2010). The adoption of six sigma in the supply chain involved many limitations and challenges. Such limitations are lack of management support, limited training opportunities, limited well trained full-time leaders, limited reinforcement, and among others (Wang et al., 2004, S. Reosekar and D. Pohekar, 2014). The high cost is also considered as a significant challenge for deploying six sigma philosophy in the supply chain (Madhani, 2016). Furthermore, it is a highly analytical method; for instance, employees require many years of statistical training, training on problem-solving tools, techniques, methods, where management policy and commitments are challenging issues in the supply chain (Moosa and Sajid, 2010).

## **2.5 Summary of literature review.**

The following section provides a summary of the review of the literature. The review of the literature provides a deeper understanding of lean, agile and six sigma developments over the last two decades in various industries in the supply chain. It reports a range of examples where lean, agile and six sigma philosophies successfully applied in the context of supply



chain management. An overview of key articles on these philosophies in the context of supply chain management is given in Table 1. This overview provides the title, author, and summary of the literature.

Table 1: An overview of key articles

<b>Title</b>	<b>Author</b>	<b>Year</b>	<b>Summary</b>
Six Sigma Implementations in Supply Chain: An Application for an Automotive Subsidiary Industry in Bursa in Turkey	Erbiyik, Hikmet Saru, Muhsine	2015	Reviewed implementation of six sigma in the automotive subsidiary industries. It emphasizes DMAIC methodology, focuses on increasing customer satisfaction, cycle time reduction and identified the cost of poor quality in the automotive subsidiary supply chain.
Performance outcomes of supply chain agility: when should you be agile?	Gligor, David M Esmark, Carol L Holcomb, Mary C	2015	Agility as an attribute closely related to the effectiveness of strategic supply chain management because of its association with the customer's effectiveness.
Lean principles, practices, and impacts: a study on small and medium-sized enterprises (SMEs)	Zhou, Bin	2016	Reviewed application of lean in SMEs and identified insights into the current status of lean and its principles, wastes elimination, practice, issues, and implementations in the SMEs.
Prioritization of six-sigma project selection: A resource-based view and institutional norms perspective	Adebanjo, Dotun Samaranayake, Premaratne Mafakheri, Fereshteh Laosirihongthong, Tritos	2016	Reviewed the selection and prioritisation of six sigma projects in the supply chain practices. It identified, how SS project selection impact on customers and suppliers in the supply chain management
Lean Six Sigma for public sector organizations: is it a myth or reality?	Antony, Jiju Rodgers, Bryan Cudney, Elizabeth A	2017	Reviewed integrated LSS application in the public sector context. Integrated LSS strategy it initiates to drive effective and efficient business process improvement in the public service sector, reduce operating cost, it could generate hard cash savings in billions of dollars in this sector.
Innovative adoption of hybrid supply chain strategies in urban local fresh food supply chain	Nakandala, Dilupa Lau, Henry CW	2019	Reviewed innovative hybrid approach of leagility (a mix of lean and agility), demonstrated to mitigate an uncertain demand for perishable products in the fresh food supply chain.

## **2.6 Hybrid philosophy**

Based on the literature review, the following sub-section outlines hybrid philosophies of Leagile and LSS in the supply chain practices. It outlines the limitations and challenges to identify the possible benefits of such improvement philosophies in the supply chain practices. It also outlines synergies between lean, six sigma, and agile in supply chain management. Finally, it outlines a theoretical framework of this research.

### **2.6.1 Leagile in the supply chain**

All businesses in the supply chain must focus on the end-user; from this perspective, both lean and agile philosophies emphasise this point (Naylor et al., 1999). According to Naylor et al. (1999), three characteristics are indicating that both lean and agile can work together as a hybrid approach in supply chain practices. These characteristics are as follows:

1. Use the market knowledge in the supply chain,
2. Integrate supply chain /value stream/virtual corporation, and
3. Lead time compression.

Lean and agile as an integrated approach works better than either approach can achieve alone in the supply chain practices (Christopher, 2000). In today's competitive business environment, a firm is capable of satisfying its diverse customer demand with product variety by integrating lean and agile strategies in the supply chain practices (Braunscheidel and Suresh, 2009). A firm can adopt agile strategies when operating in a highly uncertain environment (fluctuating demand). It can adopt lean strategies when operating in more stable environments (level schedule) in the supply chain practices (Gligor et al., 2015). In terms of volume and product variety, the two key difference, such as fluctuating demand and level

scheduling relates agility and lean to the positioning of the decoupling point (Naylor et al., 1999). For example, Figure 2 indicates the different contexts in which lean and agile philosophies might work best in the supply chain practices. This figure is indicating that lean works best in high volume, low variety in predictable environments, where manufacturing traditional products with the involvement of minimal innovation. However, the agile supply chain is most suitable for innovative products; it works in less predictable environments where demand for variety is high (Christopher, 2000). Such examples are cell phones, computers or fashion products. Furthermore, in current business practices, a hybrid form of leagile in the supply chain practices are a relatively popular topic (Singh and Pandey, 2015a).

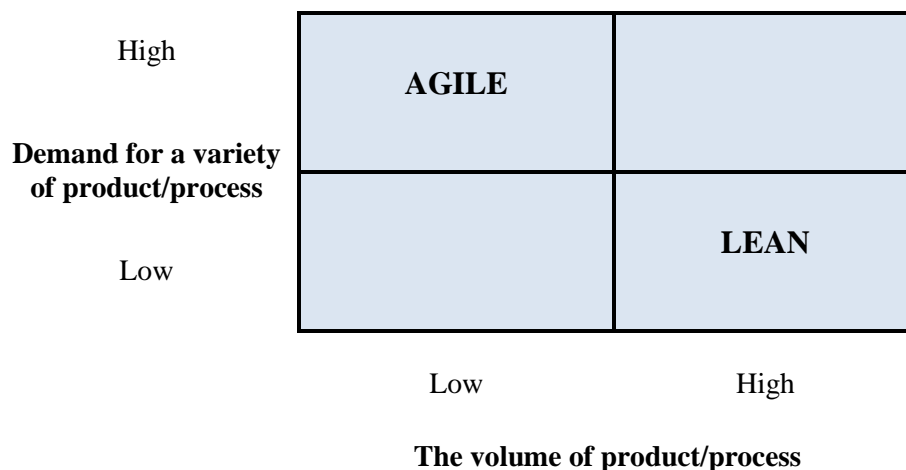


Figure 2: Application of lean and agility

Adapted from Christopher (2016)

Research indicates the adoption of hybrid philosophy (leagility) in the food supply chain context. The strategic adoption of such philosophy increases efficiency and market responsiveness in the local fresh food supply chain (Nakandala and Lau, 2018). The synergy of lean and agility works for decoupling of strategic stock or buffer stock to meet fluctuating demand in various industries, including the fresh food supply chain practices (Naylor et al., 1999, Nakandala and Lau, 2018).

### **2.6.2 LSS in the supply chain**

Both lean and six sigma are two influential improvement philosophies, the integration of lean and six sigma offers efficient and effective improvement in various areas of the supply chain practices (Antony and Kumar, 2012b). Both lean and six sigma have some common features and differences in their applications and nature.

The main difference between lean and six sigma, such as lean is a customer-oriented approach, and the six sigma approach is process-oriented. Lean philosophy observes the process from a customer point of view, where the application of lean helps to eliminate wastes to achieve process flow in the supply chain practices (Antony et al., 2016, Jenica et al., 2010, Polk, 2011). Lean is a discipline that focuses on process speed and efficiency or process flow, which could increase customer value in the supply chain. On the other hand, six sigma focuses on the impact of economic gain for organisations (the economic gains of the improvement) (Meza and Jeong, 2013). In contrast, both lean and six sigma focus on improving performance in the supply chain by improving supply chain practices (Arzu Akyuz and Erman Erkan, 2010, Eckstein et al., 2015, Jiju and Kumar, 2012). According to Shahin and Alinavaz (2008), the evaluation of lean and six sigma present in the following Figure 3.

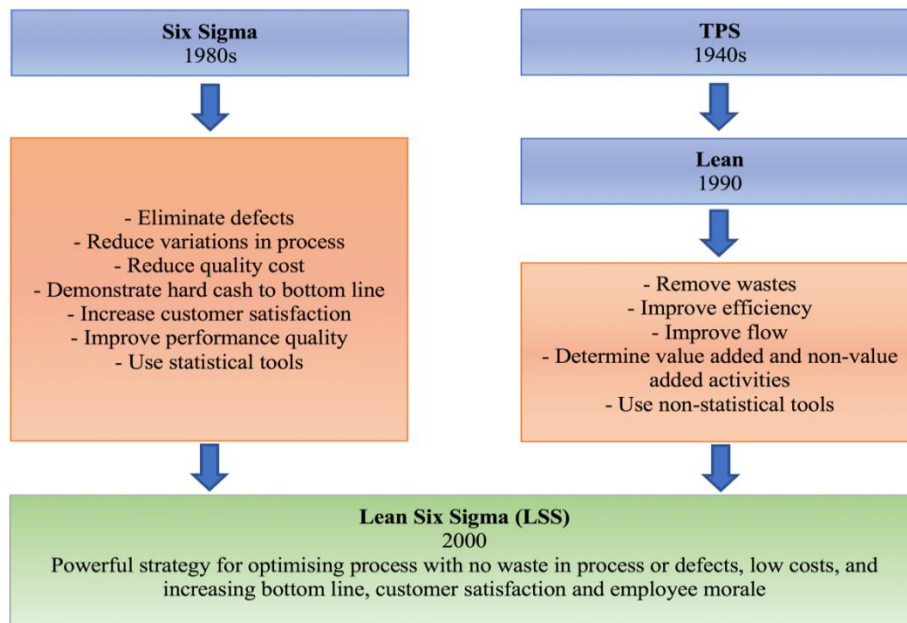


Figure 3: Integration of lean and six sigma

Reproduced from Shahin and Alinavaz (2008)

A case study research has indicated the benefits of integrating lean six sigma implementations from a call center company perspective (Laureani et al., 2010). The author identified the successful implementations of LSS in a services company reduce staff hiring costs by US\$1.3 million per year (Laureani et al., 2010). DelliFraine et al. (2010) addressed a systematic literature review on six sigma and lean in the context of the healthcare industry. They advocate that in the context of healthcare, there are relatively limited studies relating to integrated LSS specifically for clinical outcomes in the healthcare supply chain (DelliFraine et al., 2010). Table 2 present the benefits and challenges for lean and six sigma in the supply chain practices (Drohomeretski et al., 2014).

Table 2: Benefits and challenges of six sigma and lean

Methodology	Six Sigma	Lean
<b>Benefits</b>	Uniform process output Defect reduction Cost reduction Productivity improvement Customer satisfaction Make share growth Product/service development	Cycle time reduction WIP reduction Cost reduction Productivity improvement Shorten delivery time Less equipment needed Less human effort
<b>Challenges</b>	System interaction is not considered because processes are improved independently Lack of specific speed tool Long project duration	Statistical and system analysis not valued Lack of understanding lean principles Process capability and instability People issues/lack of training

Source: adapted from Drohomerecki et al. (2014), (Andersson et al., 2006)

Hilton and Sohal (2012b) have developed a conceptual model for LSS; they identified the relationship between the successful deployment of LSS and some key explanatory variables. They indicate that the successful deployment of LSS in supply chain practices improves performance. In order to develop a conceptual model, Hilton and Sohal (2012b) have considered LSS as a dependent variable and following six explanatory variables:

1. The technical skill level of the deployment facilitator,
2. The interpersonal skills level of the deployment facilitator,
3. The level of influence of the deployment facilitator,
4. The technical skills of the improvement projects leaders,
5. The interpersonal skills of the improvement project leaders, and
6. The organisational competence measured by the adherence to the various critical success factors

In order to get a better understanding of the model, they conducted preliminary interviews with senior practitioners, those who are experienced with LSS application in the supply chain. They combine the ideas from the senior practitioner with the literature review (Hilton and

Sohal, 2012a). A comprehensive literature review highlights limitations related to integrated LSS in the supply chain, tensions among integrated approaches and the challenges of integrating these approaches in the supply chain. Furthermore, the main commonalities and fundamental differences between lean and six sigma are as follows (Antony and Kumar, 2012b, Snee, 2010, Antony et al., 2017):

**Commonalities between lean and six sigma:**

- Both lean and six sigma focus on continuous business process improvement,
- Both lean and six sigma focus on business need defining by the customer,
- Both lean and six sigma are the practical method, applied in many industries, and
- Both lean and six sigma involve a comprehensive toolkit for tackling process-related problems.

**The fundamental and critical difference:**

- Lean is primarily suitable for the initial round of improvements whereas six sigma is suitable for long term and complex problems and a solution is either unknown or vaguely unknown.
- Lean requires low investment due to the nature of training and the skill to be developed as a result of this training, whereas six sigma requires high investment and it is not for fixing common sense for a problem in the business.
- Lean has less emphasis on statistical tools and techniques, whereas six sigma requires the use of the applied statistical methods of understanding and reducing variations in the processes.
- No formal organizational infrastructure requires lean implementation or deployment whereas six sigma has a well defined organizational infrastructure (Douglas et al., 2015 master black belt among others).
- Lean look into a mapping of end to end process and uses value stream exercises to understand the interactions between processes, whereas system interactions between processes are not considered in a typical six sigma problem-solving scenario.

The commonalities and fundamental differences between lean tools and six sigma tools, as shown in Figure 4.

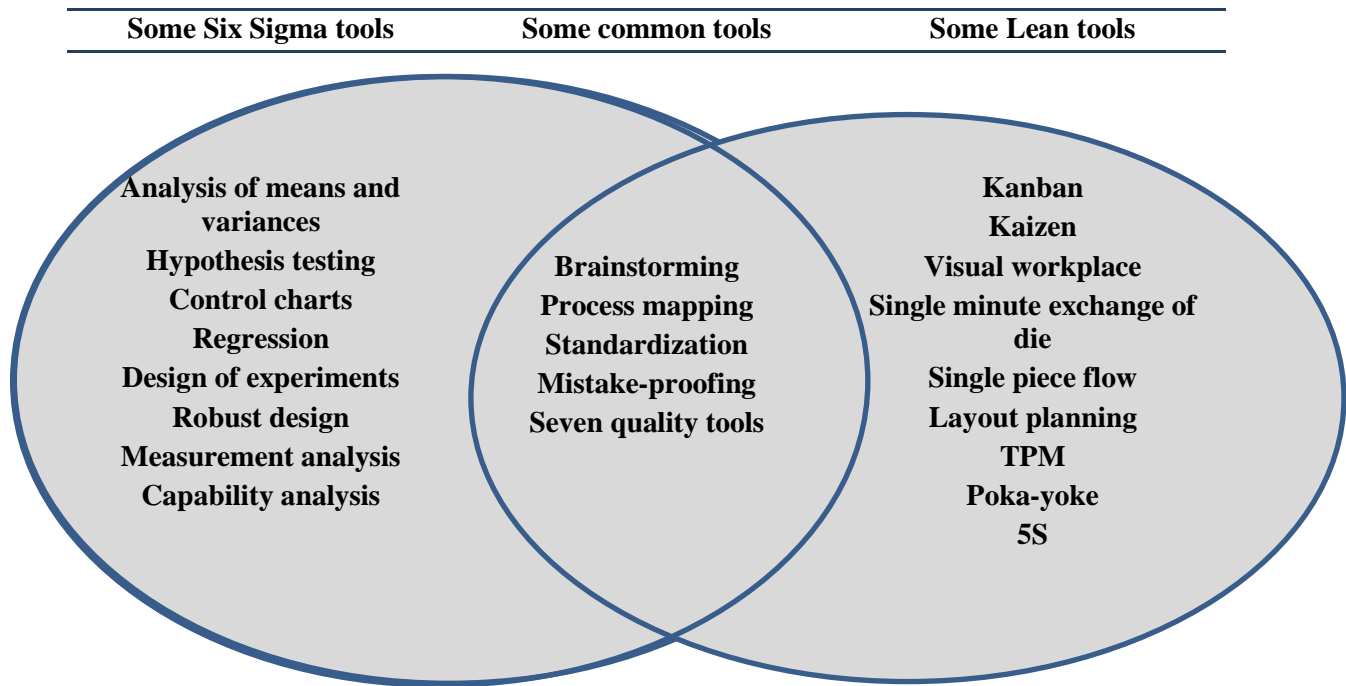


Figure 4: The Common tools of Lean Six Sigma

Adopted from Drohomeretski et al. (2014)

### 2.6.3 Theoretical framework

The integration of lean and agile (leagile/legality) or lean and six sigma (LSS) creates value in supply chain practices (Naylor et al., 1999, Snee, 2010). The integration of LSS increases the benefits by integrating the *human* (such as leadership, customer focus, cultural change among others), *process aspects* (process capability, process management, statistical thinking) and *process improvement* in the supply chain practices (Antony, 2011a, Naylor et al., 1999). The synergies of LSS eliminate rework time, improve productivity, and increase system flexibility in the supply chain practices (Drohomeretski et al., 2014, Snee, 2010). Based on the literature review, an overview of integrated L A, LSS, SSA, and LASS present in following Figure 5, which is a basic Venn Diagram.



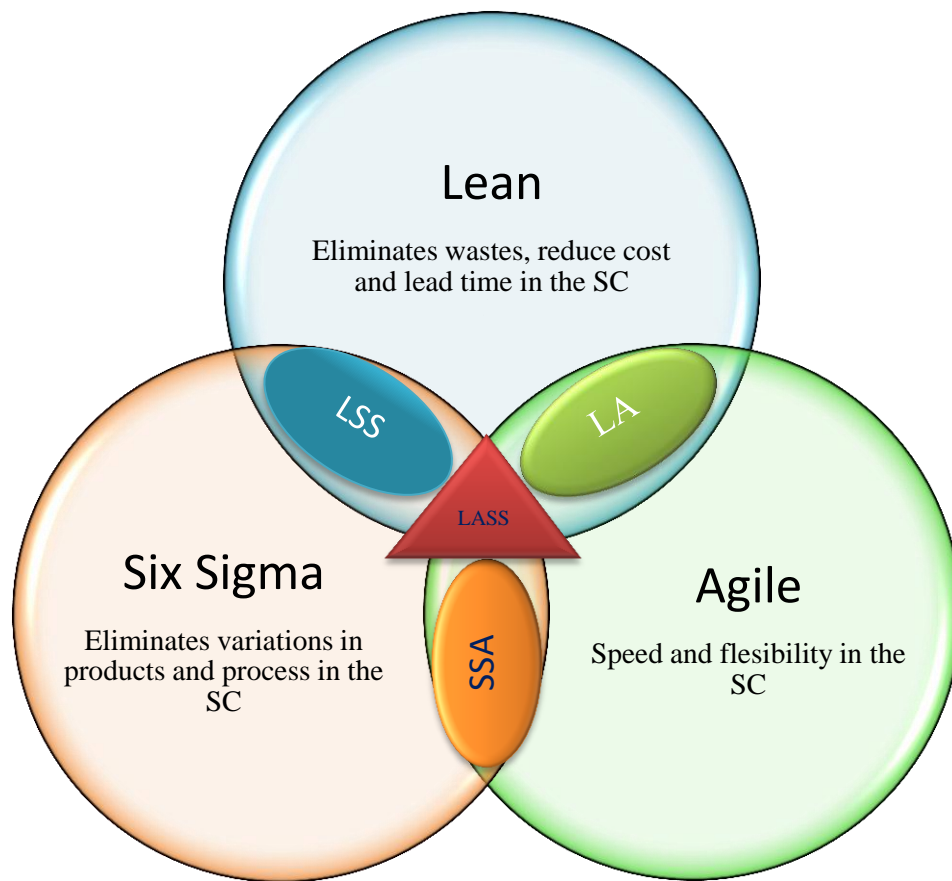


Figure 5: A summary of integrated LA, LSS, SSA and LASS in SC

Integrated LSS strategy it initiates to drive effective and efficient business process improvement in the public service sector, reduce operating cost, it could generate hard cash savings in billions of dollars in this sector (Antony et al., 2017). Similarly, integrated leagility (a mix of lean and agility), help to mitigate an uncertain demand for perishable products in the fresh food supply chain (Nakandala and Lau, 2019). A summary of integrated LA, LSS, SSA, and LASS in supply chain practices presents in the following Table 3. This summary provides tools, objectives, challenges, and industries for these integrated approaches in supply chain management.

Table 3: A summary of integrated LA, LSS, SSA and LASS approaches in SCM

Criteria	LA in SC	LSS in SC	SSA in SC	LASS in SC	References
Tools	<ul style="list-style-type: none"> <li>➤ Hybrid strategy</li> <li>➤ Speed and flexibility</li> <li>➤ Brainstorming</li> </ul>	<ul style="list-style-type: none"> <li>➤ Brainstorming</li> <li>➤ Standardization</li> <li>➤ Mistake-proofing</li> <li>➤ Seven quality tools</li> <li>➤ Hybrid strategy</li> </ul>	<ul style="list-style-type: none"> <li>➤ Brainstorming</li> <li>➤ Speed and flexibility</li> <li>➤ Cost efficiency and time responsiveness</li> </ul>	<ul style="list-style-type: none"> <li>➤ Brainstorming</li> <li>➤ Cost efficiency and time responsiveness</li> <li>➤ Hybrid strategy</li> </ul>	Naylor et al. (1999), Nakandala and Lau (2019) Soni and Kodali (2012), Christopher and Towill (2001a)
Objectives	<ul style="list-style-type: none"> <li>➤ Cost efficiency</li> <li>➤ Customer effectiveness</li> <li>➤ Lead time reduce</li> <li>➤ Leverage postponement</li> </ul>	<ul style="list-style-type: none"> <li>➤ Wastes reduction</li> <li>➤ Reduce Non value added activities and</li> <li>➤ Lead time reduce</li> </ul>	<ul style="list-style-type: none"> <li>➤ Cost reduction</li> <li>➤ Lead time reduction</li> <li>➤ Quality improvement</li> </ul>	<ul style="list-style-type: none"> <li>➤ Cost efficiency</li> <li>➤ Lead time reduce</li> </ul>	Lotfi and Houshmand (2015), Naylor et al. (1999), Antony et al. (2012), Drohomerski et al. (2014)
Challenges	<ul style="list-style-type: none"> <li>➤ Unpredicted change</li> <li>➤ Supply and demand uncertainty</li> <li>➤ Lack of top management support</li> <li>➤ Fundamental shift of stakeholder thinking</li> </ul>	<ul style="list-style-type: none"> <li>➤ Lack of specific speed tools</li> <li>➤ Fundamental shift of stakeholder thinking</li> <li>➤ Lack of awareness</li> <li>➤ Lack of top management support</li> </ul>	<ul style="list-style-type: none"> <li>➤ Long project duration</li> <li>➤ Lack of awareness</li> <li>➤ Fundamental shift of stakeholder thinking</li> <li>➤ Lack of top management support</li> </ul>	<ul style="list-style-type: none"> <li>➤ Fundamental shift of stakeholder thinking</li> <li>➤ Lack of top management support</li> </ul>	Christopher et al. (2004), Antony and Kumar (2012b), Snee (2010), Drohomerski et al. (2014)
Industries	<ul style="list-style-type: none"> <li>➤ Fashion Industry</li> <li>➤ Manufacturing</li> <li>➤ Food supply chain</li> </ul>	<ul style="list-style-type: none"> <li>➤ Manufacturing</li> <li>➤ Healthcare service</li> <li>➤ SMEs</li> <li>➤ Non- profit organisation</li> </ul>	<ul style="list-style-type: none"> <li>➤ Manufacturing</li> <li>➤ Healthcare service</li> <li>➤ SMEs</li> <li>➤ Non- profit organisation</li> <li>➤ Fashion Industry</li> </ul>	<ul style="list-style-type: none"> <li>➤ Manufacturing</li> <li>➤ Healthcare service</li> <li>➤ SMEs</li> <li>➤ Non- profit organisation</li> <li>➤ Fashion Industry</li> <li>➤ Food Supply Chain</li> </ul>	Snee (2010), Antony and Kumar (2012b), Cheng and Chang (2012), Swafford et al. (2006), Drohomerski et al. (2014), Cheng and Chang (2012), (Adebanjo et al., 2016b)

Based on the above literature review, the key point is that the application of leagility or LSS in the supply chain practices makes it possible to gain a competitive advantage compared to the isolated application of these philosophies alone. Since agility is a business-wide capability that embraces organisational structure, the combination of an agility attribute with LSS could be a dominant improvement philosophy in the supply chain practices. While all businesses in any supply chain must focus on the end-user, from this perspective, both lean and agility improvement philosophies emphasise this point (Naylor et al., 1999). Equally, the six sigma improvement philosophy also embraces end user philosophy. In addition, the integrated LSS application is efficient than these philosophies in isolation use in the supply chain practices. Similarly, the combination of lean agility leads to enhance performance in the supply chain.

Until now, there is relatively limited literature that has evidenced three approaches of lean, agile and six sigma (LASS) application in one supply chain practices. Also, the outcome of the critical literature review indicates that there are many limitations and challenges of integrating these philosophies in the supply chain practices.

The critical literature review of this study provides a deeper understanding of hybrid approaches of lean, agile and six sigma developments over the last two decades, including integrated LSS, LA and SSA philosophies adoption across various industries in the supply chain practices. Thus, key themes covered in the critical literature review include integrated improvement methods from the perspective of challenges, opportunities, and benefits for various industries in the context of supply chain management (e.g. down-stream and up-stream). Furthermore, this study adopted a systematic literature review as a research methodology and its respective outcomes will be discussed in the upcoming Chapter 3.

## **CHAPTER 3: RESEARCH METHODOLOGY**

### **3.1 Introduction**

The previous chapter outlined the critical literature review for this study. This chapter introduces the research methodology by outlining the importance of literature reviews in management research and outlines various systematic review methods used for supply chain management. It also outlines details of the three-stage method adapted for this study.

### **3.2 Methodology**

Methodology refers to the overall approach to the research process, from the theoretical underpinning to both data collection and data analysis. Methodology means systematically solve a specific issue or a research problem. To this end, considering an appropriate research methodology is vital to solving a specific issue or a research problem (Gray, 2013). Methods, on the other hand, refer to the various means by which data can be collected and analyzed (Collis and Hussey, 2013).

This research uses a systematic literature review, a method of collecting available literature in a systematic way (Tranfield et al., 2003). Systematic reviews are a rigorous process, and it helps to identify, evaluate and clarify all available evidence to a specific inquiry for a topic (Kitchenham, 2004). In particular, a systematic review is a tool to review evidence-based literature in a particular field, which is a highly rigorous method (Higgins and Green, 2011). To this end, a useful literature review provides an appropriate breadth and depth of existing research. Indeed, the literature review plays an essential role in management research.

### **3.2.1 The importance of a literature review in management research**

A literature review is a key tool in management research, as it helps to manage the diversity of knowledge for a specific academic inquiry (Tranfield et al., 2003). A literature review is important in management research for many reasons. The two important reasons are 1) a literature review helps to summarise existing research by identifying patterns, themes and issues, and 2) this helps to identify the conceptual content of the particular field and can contribute to developing a theory for particular inquiry (Meredith, 1993). Furthermore, a literature review is the backbone of every academic piece of writing (Seuring and Gold, 2012). A literature review is considered as a research method in its own right (Jesson et al., 2011).

There are two dominant styles of literature review: traditional literature review and systematic literature review. In management research, both traditional reviews and systematic reviews are essential. In particular, a literature review informs readers about the current state of knowledge on a particular topic and equally helps to establish a need for additional research or another goal (MacIntosh and D O'Gorman, 2015, Sekaran and Bougie, 2011). In addition, a useful literature review gathers information for a topic from many sources. It is used to assess the existing intellectual territory to specify a research question and to develop a knowledge base (Cronin et al., 2008).

However, some researchers argue that the traditional literature reviews frequently lack thoroughness and bias by the researchers, often lacking rigour than a systematic review (Tranfield et al., 2003, Glass et al., 1981). One of the fundamental differences between a traditional literature review and a systematic review is an unbiased search. A systematic literature review helps to identify a comprehensive, unbiased search (Tranfield et al., 2003). As such, in a systematic review process, it is significantly essential to develop a search

strategy to identify the relevant resources. However, there are no specific search strategies that require traditional literature when extracting data or synthesising the main points, issues, and findings in the review process (MacIntosh and D O'Gorman, 2015). A lack of explicit methods and a minimum rigorous definition are the main criticisms behind the traditional literature review process (Glass et al., 1981, Mulrow, 1994). As a result, the findings of many reviews are biased in many ways in the traditional literature review process (Glass et al., 1981).

In contrast, explicit and more rigorous methods are involved in minimising biases in a systematic review process (Mulrow, 1994). A Systematic review is leading to improve reliability and accuracy for creating a new knowledge base for research (MacLure et al., 2016). In practice, there are some similarities and differences that exist between a systematic literature review and a traditional literature review. The main similarities and differences are shown in Appendix 1 (Bettany-Saltikov, 2010). Furthermore, the basic principles of systematic review have been considered and adopted in a range of research areas/disciplines, including supply chain management research (Tranfield et al., 2003). The following are fundamental principles of the systematic literature review process.

**(a) Clarity:** It is essential to create a clear structure to establish a precise method for the review and document the searching process. The precise structure will allow readers to justify the review processes and ensure that all decisions are made valid (Tranfield et al., 2003).

**(b) Validity:** To validate the review process, it is essential to establish inclusion and exclusion criteria based on the scope of the study. To avoid selection bias, the rationale behind the searching process needs to support the theme of the study. As a result, the review can be repeated to test its rigour and validity (Denyer and Neely, 2004).

**(c) Auditability:** The search strategies of the review must be recorded accurately in a table.

This record will allow readers to justify the search results and review process. The extent of the review process ensures that there is a close relationship between clearly formulated research questions and the identification of evidence that informs such questions clearly (Petticrew and Roberts, 2008).

### **3.2.2 Systematic review method**

The systematic review method provides adequate insight and guidance to map and assess existing intellectual evidence for developing a knowledge base for research (Tranfield et al., 2003, Mulrow, 1994). A systematic literature review is influenced by rigorous methodological guidance (Tranfield et al., 2003).

Petticrew and Roberts (2008) emphasise that systematic reviews are methods for making sense of a large volume of information. They make a significant contribution to the notion of social science and articulate a seven-stage approach. The seven stages are structured to maintain chronological order, and the stages are easy to follow. However, Norton (2008) argues that the seven stages offer relatively little guidance for developing a review protocol. A review protocol is a formal document or plan that provides a clear description for defining the necessary steps for a review procedure (Tranfield et al., 2003).

Tranfield et al. (2003) propose a three-stage systematic review method, as shown in Figure 6. The three stages are (1) planning the review; (2) conducting the review; and (3) reporting and dissemination; the stages also involve several sub-processes.

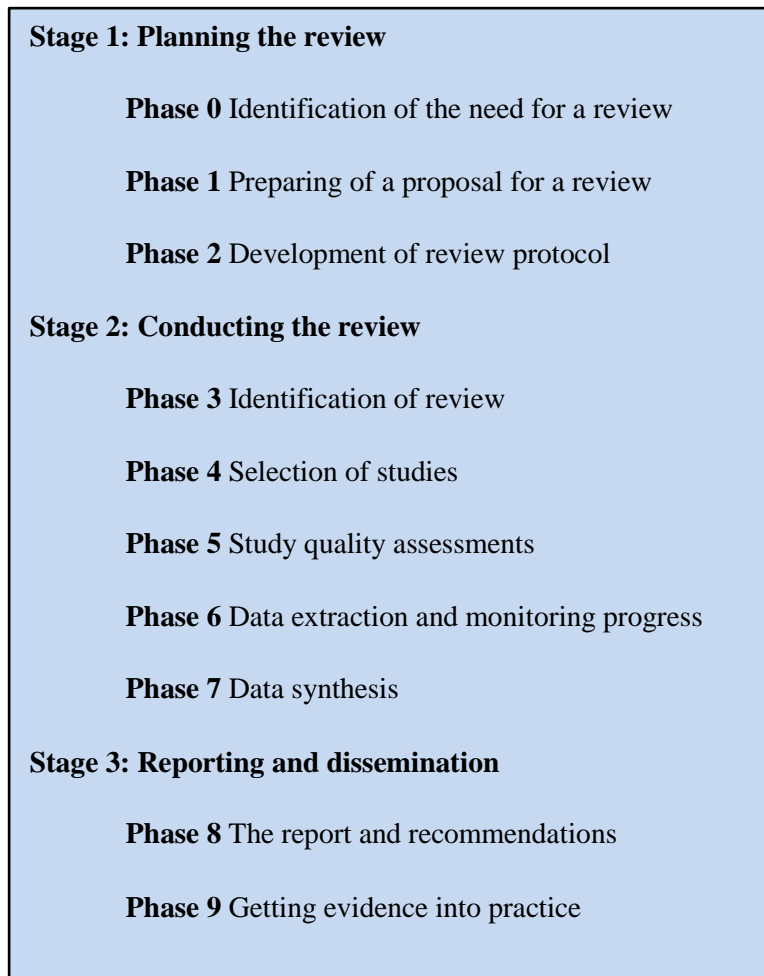


Figure 6: Three-stage approach

Adopted from Tranfield et al. (2003)

Despite the relative infancy of systematic literature review in management research, its various methods have received considerable attention in many disciplines, including supply chain management research (Tranfield et al., 2003). Many researchers have applied the influential five-stage review method in supply chain management research (Derwik and Hellström, 2017, Zimmermann et al., 2016, Mustafa Kamal and Irani, 2014). Wang et al. (2016) have demonstrated a framework on the application of big data business analytics within logistics and supply chain management literature. To provide a better understanding of



supply chain integration through a systematic literature review, Mustafa Kamal and Irani (2014) analysed literature from a normative perspective. They adopted the research methodology proposed by Tranfield et al. (2003). According to Denyer and Tranfield (2009), a five-step method as shown in Figure 7.

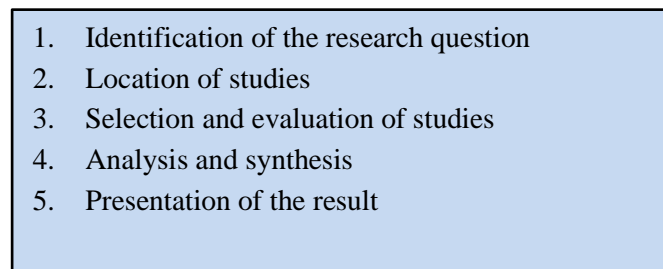


Figure 7: Five-stage approach

Denyer and Tranfield (2009)

Derwik and Hellström (2017) have applied the three-stage approach to develop a coherent body of knowledge for all dimensions of competence in supply chain management. In a systematic literature review, Shukla and Jharkharia (2013) analysed literature according to geographic region and year of publication in the context of agri-fresh food supply chain management. They adopted a framework in their research, which is proposed by Mayring (2010).

### **3.2.3 Method adopted for this study**

This study adopted a three-stage systematic review method, according to Tranfield et al. (2003). The following section presents details of the method that has been adopted for this study.

### 3.3 Planning the review

A review protocol is developed to achieve the objectives of this research study. The need for the review and a clear scope have been presented in the introduction section of the study. The focus of this study is to explore challenges and limitations to identify possible benefits of hybrid approaches of lean, agile, and six sigma philosophies in supply chain management. According to Tranfield et al. (2003), this study adopted three stages of systematic review method to ensure a transparent and reproducible evaluation of relevant literature. The three-stage method is shown in Figure 8 (Tranfield et al., 2003, Okoli and Schabram, 2010):

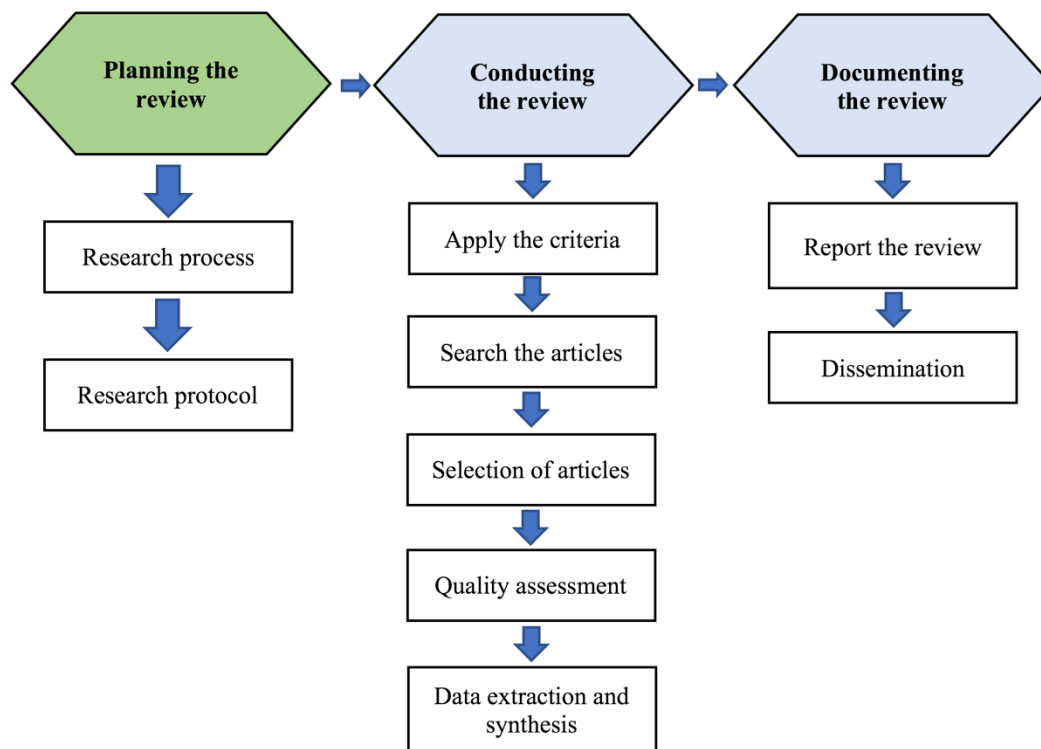


Figure 8: Three stages of the systematic review process

Adopted from Okoli and Schabram (2010)

By considering the three-stage systematic review method, a search strategy was developed for the identification of the relevant literature for this study. The search strategy helps to broaden

or narrow the result based on the appropriate keywords and search terms (Derwik and Hellström, 2017). In this context, the most appropriate keywords, search terms, and search strings have been considered for this study to locate and extract relevant literature within the scope of the research. Thus, this study strictly considers ten processes/steps as the main strategy of the review method. Details of the strategy, including the definition of each step, are presented in Table 4.

Table 4: Strategy of the review method

Process	Definitions
1. Defined research purpose and objectives	The purpose of the research and the objectives are clearly defined for this review. The identification of the need for the review is clearly stated in the introduction section.
2. Developed research protocol	The research protocol was developed around the central research question by following the three stages method to answer the sub-research questions.
3. Established relevance search criteria	The inclusion and exclusion criteria clearly stated to identify the most relevant articles for the study.
4. Conducted searches and retrieve the articles	Electronic search has been conducted in the scholarly databases (ProQuest, EBSCO, and Google Scholar) to collect peer-reviewed journal articles for this review.
5. Collected relevant articles	Strictly considered the inclusion and exclusion criteria of the review to collect relevant articles.
6. Quality assessment for the relevant articles	The relevant articles were considered from published, peer-reviewed scholarly journals only to maintain the quality of the literature (implicit quality rating of a journal considered).
7. Data extraction	Research data extracted related to the theme of the study.
8. Synthesis of articles (analysis)	The synthesis of articles focuses on integrating improvement philosophies of Lean, Six Sigma and Agility (LSSA) in the context of SCM
9. Reporting	The reporting included the distribution by year of the publications and distribution by sources of the publications for the review.
10. Dissemination	This review is preparing to publish in an academic journal as the contribution of the knowledge.

Based on the scope of the research, this study established the inclusion and exclusion criteria of the research. The inclusion and exclusion criteria are shown in the following Table 5. The criteria of the study indicate that the time frame has been considered from 2008 to date for this review. Researchers indicate that before 2008, there is relatively limited literature related to integrated LSS or LA approaches in supply chain practices (Gunasekaran et al., 2004,

Swafford et al., 2006). As such, to answer the research questions of the study, this time frame is chosen for locating and extracting available articles from the databases (ProQuest and EBSCO and Google Scholar). The research questions have already been defined in the introduction section of this study. Furthermore, peer-reviewed journal publications have been included in the review, and articles published in the English language were included only.

Table 5: Inclusion and exclusion criteria for the review

Inclusion	Exclusion
Year of publication: from 2008 to date	Any publication before the year 2008
Databases: ProQuest ABI/INFORM Collection, EBSCO, Google Scholar (used for general search)	Other databases (produce similar output)
Journals: Peer-reviewed, Full text Source type: Scholarly journal Document type: Articles Language: English	Online sites and grey literature (conference, report, working papers from research groups, technical reports) Any other languages
Books (no time restrictions were applied to books)	N/A

### 3.4 Conducting the review

The following subsection outlines the details of the systematic searching process and the article selection process for this review. The inclusion and exclusion criteria are strictly applied to conduct an effective and reproducible database search for the study.

#### 3.4.1 Systematic searching process

A systematic searching technique has been applied to cover a broad range of databases to identify the relevant articles within the scope of the research. According to Tranfield et al. (2003), a systematic search begins with the identification of keywords and search terms. Hence, this research aims to explore challenges and limitations to identify possible benefits of LASS application in the context of supply chain management for various industries. From this end, a keyword search was performed to ensure that all relevant studies were included. To

identify the relevant articles related to the theme of the study, the following keywords were used: ‘Lean’, ‘Six Sigma’, ‘Agility’, ‘responsiveness’ and ‘supply chain performance’. Search terms such as ‘principles’, ‘techniques’, ‘Lean Six Sigma’, and ‘Lean Agility.’

The search was conducted according to the inclusion and exclusion criteria of the study. For example, Derwik and Hellström (2017), applied seven steps process to avoid personal preferences and selectivity to identify relevant literature for a study. Higher-Level search strings were set to identify the relevant articles for this study. Each search was entered in a single search string. The Boolean operators (AND, OR) have been used in the search string to join the search terms. In a systematic review, an appropriate search string is significantly essential to identify the expected search result for a study (Tranfield et al., 2003). For example, to identify and extract relevant articles for sustainable supply chain quality management research, Bastas and Liyanage (2018) applied a higher level of the search string to identify an integrated result for quality management, supply chain management, and sustainability management.

This study uses the following search strings (agreed with the supervisors) to identify the expected articles to review:

- **Search 1:** ((Lean principles) OR (Lean techniques)) AND ((Six Sigma principles) OR (Six Sigma techniques)).
- **Search 2:** (((Lean principles) OR (Lean techniques)) AND ((Six Sigma principles) OR (Six Sigma techniques))) AND ab(((Lean) AND (Six Sigma))).

The search resulted in 1046 peer-reviewed articles from the ProQuest database. This search was then modified by entering an abstract in the document fields. The modified search

resulted in 121 articles. A similar technique was applied to cover all possible combinations of keywords and search terms identified for this study, and these are presents in Table 6.

Table 6: Search strings/keywords and search terms

Search strings	Keywords and search terms	Search results
((Lean principles) OR (Lean techniques)) AND ((Six Sigma principles) OR (Six Sigma techniques))	Key: Lean and Six Sigma Search terms: principles and techniques	1046 articles
((Lean principles) OR (Lean techniques)) AND ((Six Sigma principles) OR (Six Sigma techniques)) AND ab(((Lean) AND (Six Sigma)))	Search modified by entering 'abstract' in the document field for lean AND Six Sigma + considered most cited and relevant articles	121 articles
((Lean principles) OR (Lean techniques)) AND ((Agility) OR (responsiveness))	Key: Lean and Agility Search terms: principles, techniques, and responsiveness	1257 articles
((Lean principles) OR (Lean techniques)) AND ((Agility) OR (responsiveness)) AND ab(((Lean) AND (agility)))	Search modified by entering 'abstract' in the document field for lean AND agility + considered most cited and relevant articles	17 articles
((Six Sigma principles) OR (Six Sigma techniques)) AND ((Agility) OR (responsiveness))	Key: Six Sigma and Agility Search terms: principles, techniques and responsiveness	374 articles
((Six Sigma principles) OR (Six Sigma techniques)) AND ((Agility) OR (responsiveness)) AND ab(((Six Sigma) OR (Agility)))	Search modified by entering 'abstract' in the document field for Six Sigma AND agility + considered most cited and relevant articles	52 articles
((Lean principles) OR (Lean techniques)) AND ((Six Sigma principles) OR (Six Sigma Techniques)) OR ((Lean Six Sigma) OR ((Lean Agility))AND ((Agility) OR (responsiveness))) AND (supply chain performance)	Key: Lean, Six Sigma, Agility and supply chain performance Search terms: principles, techniques, responsiveness, Lean Six Sigma and Lean Agility	213 articles
((Lean principles) OR (Lean techniques)) AND ((Six Sigma principles) OR (Six Sigma Techniques)) OR ((Lean Six Sigma) AND ((Agility) OR (responsiveness))) AND (supply chain performance)) AND ab((((Lean) AND (Six Sigma)) OR ((Agility) AND (Supply chain performance))))	Search modified by entering 'abstract' in the document field for ((Lean) AND (Six Sigma)) OR ((Agility) AND (Supply chain performance)) + considered most cited and relevant articles	25 articles

In order to ensure coverage of recent publications, the same keywords searches applied in both the Google Scholar and the Scopus databases to locate articles. Both databases produced a large number of articles with an almost similar title. To ensure the reliability of the process of finding and selecting the articles, results from all databases are cross-checked. However, by following the above search technique, relatively limited articles have been found related to the integrated approach of six sigma and agility (SSA) application in the supply chain. Therefore, the search has been extended to a general search on the Google Scholar database. The general search resulted in an additional five articles; these are relevant to the theme of the topic.

Table 7 presents search results at a glance, which indicates both the keyword search result and the modified search result for this review. The results indicate the variations when restricting the search terms to appear in the ‘abstract’ of the document field. Also, Appendix 2 presents the full details of the steps taken for article searches for this study. These searches are reproducible and auditable.

Table 7: Search results at a glance

Search result	Modified search result
1046	121
1257	17
374	52
213	25
2890 total articles	215 total articles

### 3.4.2 The article selection process

As showing in Table 8, keyword searches resulted in a total of 2890 articles, and the modified searches resulted in a total of 215 articles. At this stage, 36 articles were eliminated from the modified search result due to duplication. A skim-reading was conducted through the remaining 179 articles. By considering the skim reading process, 66 articles were excluded due to being less relevant, and 113 articles were considered to review. The articles were only included if all criteria fully met with the inclusion and exclusion criteria of the study.

However, to cover all relevant articles related to the theme of the topic, five articles (seminal papers) were included from the general search. The general search has conducted in the Google Scholar database. Figure 9 presents a flowchart of the article selection process.

Finally, 118 articles were found to be relevant to the topic.

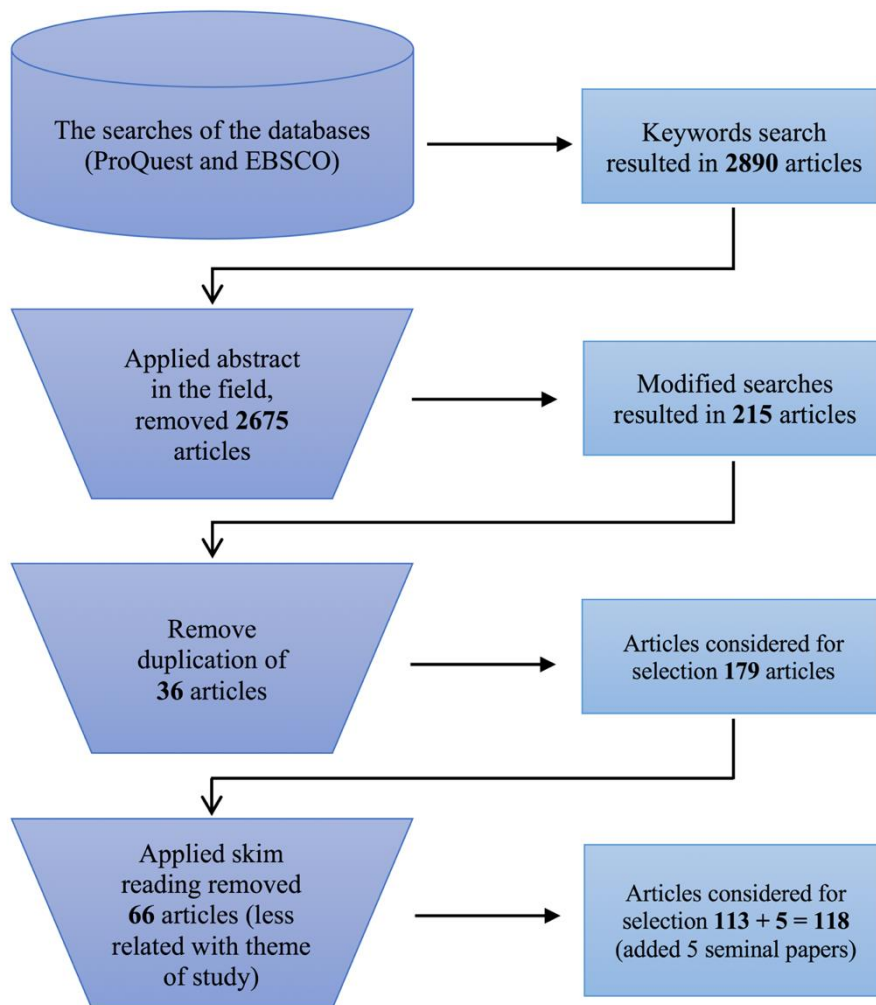


Figure 9: Flowchart of the article retrieval process

Adapted from Derwik and Hellström (2017)

Based on the scope of the study, 118 articles have been selected and saved electronically into an EndNote library. The selected articles have been reviewed and synthesised for this research. The distribution and analysis of these articles are presented in the following subsection.



### 3.5 Article distribution and analysis

In this section, the final sample of 118 articles will be examined considering the distribution by year of publication, distribution by the source of publication and methodology used for the selected article. Finally, a list of key articles for this review is given.

#### 3.5.1 Distribution of articles by year of publication

The articles distribution by year of publication in Figure 10 is indicating that most of the articles identified are quite recent. The articles related to integrated approaches of Leagile/ Legility or LSS are a relatively new theme in the supply chain management literature. This figure shows that a number of publications were found to rise significantly from 2012 to 2016. This increase in publications indicates a growing research interest in integrated approaches of lean, six sigma and agile in the supply chain practices.

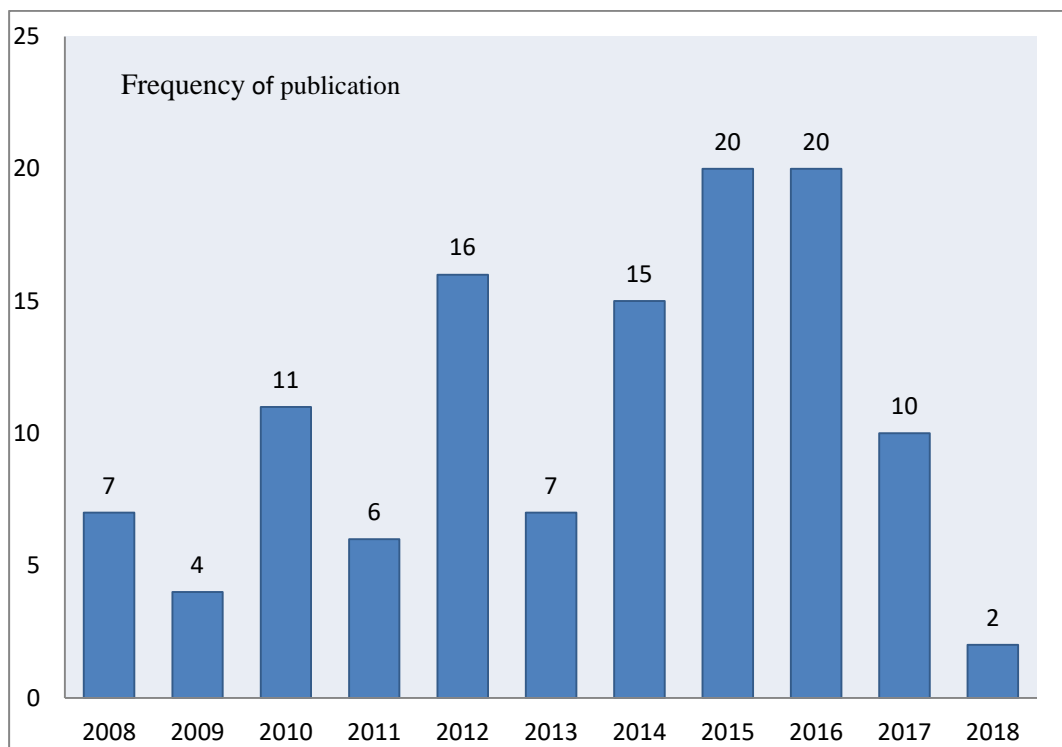


Figure 10: Distribution by year of publication

### 3.5.2 Distribution by sources of publication

This subsection represents the distribution of the articles by the source of publication. The articles have been selected for the study was published in 40 different journals. The journals with the most significant number of publications are the *International Journal of Quality & Reliability Management*, *SCM: An International Journal*, *International Journal of Operations & Production Management*, *International Journal of Lean Six Sigma*, and *International Journal of Productivity and Performance Management*. The name of the journals and numbers of articles are presented in Table 8.

Table 8: Main source of articles

No	Name of Journal	Number of articles
1	International Journal of Quality & Reliability Management	11
2	Supply Chain Management: An International Journal	10
3	International Journal of Operations & Production Management	9
4	International Journal of Lean Six Sigma	7
5	International Journal of Productivity and Performance Management	7
6	International Journal of Production Research	6
7	Benchmarking: An International Journal	6
8	Quality Management Journal	5
9	Production Planning and Control	4
10	International Journal of Production Economics	4
11	TQM Journal	3
12	Business Process Management Journal	3
13	International Business & Economics Research Journal	3
14	Journal of Operations Management	3
15	Journal of Manufacturing Technology Management	2
16	Journal of Modelling in Management	2
17	Economics and Management	2
18	Supply Chain Management	2
19	Journal of Business and Retail Management	2
20	Journal of Applied Business Research	2
21	Quality Innovation Prosperity	2
22	Journal of Manufacturing System	2

<b>No</b>	<b>Name of Journal</b>	<b>Number of articles</b>
23	Advance Material Research	2
24	International Journal of Business and Management	2
25	Organisations Technology and Management in Constriction	2
26	Management and Production Engineering Review	1
27	IUP Journal of Operations Management	1
28	Annals of Operations Research	1
29	Engineering Management Journal	1
30	Procedia – Social and Behavioural Science	1
31	Journal of Management Policy and Practice	1
32	International Journal of Logistics Management	1
33	International Journal of Clinical Pharmacy	1
34	Decision Science Journal of Innovation Education	1
35	European Research on Management and Business Economics	1
36	Constriction Innovation	1
37	International Journal of Construction Project Management	1
38	Journal of Management in Engineering	1
39	Journal of Supply Chain Management System	1
40	International Journal of Physical Distribution and Logistics Management	1
	Total number of articles	118

### **3.5.3 Methodology used for the selected article:**

Considering the methodologies for 118 articles of this study, the majority of the publications related to integrated LSS and Leagile in the context of the supply chain includes case studies, literature reviews, models, surveys, and theoretical and conceptual frameworks. The most common methods used in this study are literature reviews, models and theoretical and conceptual frameworks. The distribution of research methodology for 118 articles is presented in Figure 11.

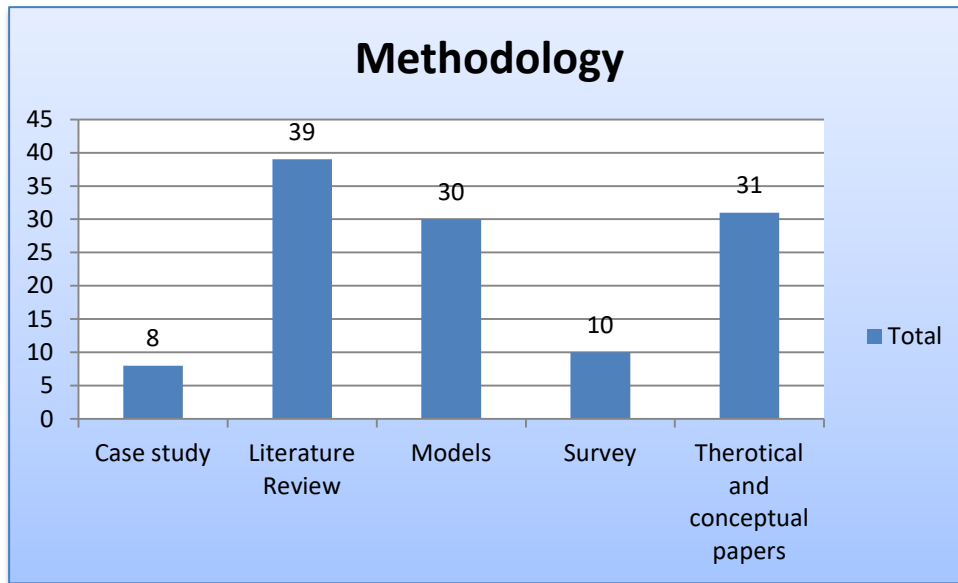


Figure 11: Distribution of research methodology

A critical literature review has been conducted on 118 articles to extract the research data for this study. The data extraction focuses on hybrid approaches of lean, agile and six sigma philosophies in supply chain management for various industries. An overview of the key articles presents in the following Table 9; this overview provides the author and year, the title, methodology, and method used for this study.

Table 9: A lists of key articles

Author & Year	Title	Methodology	Method
Mustafa Kamal and Irani (2014)	Analysing supply chain integration through a systematic literature review: a normative perspective.	This paper applied a SLR for developing theory-building relating to supply chain integration.	Uses the three-stage SR method; this paper identified the insight of intellectual wealth to the SCI and SCM area.
Albliwi et al. (2014a)	Critical failure factors of Lean Six Sigma: a systematic literature review	This paper applied a SLR and analysed 56 papers related to lean, six sigma published between 1999 to 2013.	This paper adopted the three-stage method and identified 37 failure factors related to integrated LSS

<b>Author &amp; Year</b>	<b>Title</b>	<b>Methodology</b>	<b>Method</b>
Abu Bakar et al. (2015)	Critical success factors of Lean Six Sigma deployment: a current review	This paper applied a comprehensive literature review to investigate the critical success factor of LSS.	This paper adopted a hybrid method of LSS, which is more powerful, effective and efficient.
Albliwi et al. (2015)	A systematic review of Lean Six Sigma for the manufacturing industry	This paper applied a SLR, and analysed 37 peer-reviewed journal articles from 2000 to 2013 for manufacturing Industry perspective.	This paper adopted a three-stage method.
Singh and Pandey (2015a)	Lean Supply-Chain: a state-of-the-art literature review	This paper applied for a state-of-the-art literature review.	This paper adopted a survey method, identified leanness in the supply chain to maximise profit through cost reduction, indicates hybrid from of Leagile in the supply chains
Samaranayake and Laosirihongthong (2016)	Configuration of supply chain integration and delivery performance: Unitary structure model and fuzzy approach	Twofold methodology, developed a conceptual framework of integrated supply chain and illustration of an integrated supply chain model	This study used a case study and survey method
Zhou (2016b)	Lean principles, practices, and impacts: a study on small and medium-sized enterprises (SMEs)	This study examines factors (managers, people related, key knowledge and know-how) associated with Lean implementations in SMEs in the US.	A hierarchical cluster analysis.
Albliwi et al. (2017)	Implementation of Lean Six Sigma in Saudi Arabian organisations	This paper applied an SLR based on a detailed survey questionnaire focused on 400 Saudi Arabian organisations.	This paper adopted a survey method, identified Lean Six Sigma is still in its early stages in the Saudi Arabian industries
Fatima et al. (2018)	International Journal of Quality & Reliability Management	This paper analysed 611 participants (indoor and outdoor patients), and the relative significance of quality measurements for patient satisfaction and loyalty.	This paper applied the survey method-specific focused on hospital services quality in Islamabad, Pakistan.

<b>Author &amp; Year</b>	<b>Title</b>	<b>Methodology</b>	<b>Method</b>
Antony et al. (2017)	Lean Six Sigma for public sector organisations: is it a myth or reality?	This paper critically evaluates the application of LSS in various public sector contexts based on the UK and demonstrated four case studies from four different public sector organisations.	This paper applied a case study method with a specific focus on public sector organisations.
Al Owad et al. (2018a)	An integrated lean methodology for improving patient flow in an emergency department: a case study of a Saudi Arabian hospital	This paper presents an integrated Lean methodology (voice of process, the voice of customer and voice of staff) for improving patient flow in the emergency department (ED) in a Saudi Arabian hospital.	To identify sources of wastes in ED of the hospital, this paper applied process mapping and A3 problem-solving sheet as visual tools and reveals that these wastes are related to quality management (facilities, patients, physicians, nurses, administration, data/information).
(Nakandala and Lau, 2018)	Innovative adoption of hybrid supply chain strategies in urban local fresh food supply chain	This paper presents a hybrid (Aronsson et al.) supply chain strategies in the urban local fresh food supply chain.	This study uses a case study method to find insight on fresh food supply chains with a \ specific focus on 12 urban fresh food retailers in Sydney; interview data were analysed using thematic analysis.

Hence, this study seeks to explore the challenges and limitations to identify possible benefits of integrated LASS application in the supply chain practices. In this regard, the following chapter presents the analysis of publications related to integrated LA, LSS, SSA, and LASS in the supply chain practices.

## **CHAPTER 4: ANALYSIS**

### **4.1 Introduction**

The previous chapter outlined the research methodology following a three-stage systematic literature review method. This chapter presents an analysis of publications used for the study. It also presents a critical literature review analysis for this study.

### **4.2 The analysis of publication**

The article distribution and analysis in Chapter 3, section 3.5 of this study indicates, before 2008, there are very fewer publications on integrated LA, LSS, or SSA approaches in supply chain management literature. In recent times there are few publications identified related to such approaches in the supply chain practices (Antony et al., 2016, Drohomiretski et al., 2014, Habidin and Yusof, 2012, Jiju and Kumar, 2012, Meza and Jeong, 2013, Pillai et al., 2012, Snee, 2010, Nakandala and Lau, 2019). A recent study carried out by Nakandala and Lau (2019) has shown that a lack of studies on extending the literature related to integrated legality on the fresh food supply chain. Although there is significant evidence on integrated LSS application for manufacturing and services industries, however the lack of studies on LSS in the context of higher education still exists (Antony et al., 2012, Antony et al., 2017, Cheng and Chang, 2012). In particular, evidence shows that research in such integrated philosophies in the supply chain management literature is relatively lacking (Cheng and Chang, 2012, Jiju and Kumar, 2012, Snee, 2010).

### **4.3 Analysis of critical literature review**

Based on the critical literature review, most of the articles related to the theme of the topic are indicating the integration of two approaches such as LA or LSS in the supply chain rather than integrated LASS (lean, agile and six sigma). With regards to the integrated LA or LSS adoption in the supply chain, many studies are focusing on manufacturing, financial services, automotive services, healthcare services, educational sector, and public services organisations including the agri-food supply chain sector (Antony and Kumar, 2012b, Antony et al., 2017, Cheng and Chang, 2012, Erbiyik and Saru, 2015, Nakandala and Lau, 2019, Antony et al., 2012). For example, in the context of the fresh food supply chain, Nakandala and Lau (2019) have shown, the adoption of hybrid strategy (Legality) initiates to increase time efficiency and product variety where retailers have active collaboration throughout the upstream and downstream supply chains. In addition, the evidence of integrated LSS to healthcare services, financial services, educational sectors, and public services sectors have been explored in the supply chain practices (Antony and Kumar, 2012b, Antony et al., 2017, Snee, 2010, Timans et al., 2012). Antony and Kumar (2012b) have shown the evidence of LSS in National Health Services (NHS) in the UK; the applications of LSS reduce patient waiting time and improve the physical flow of material in hospitals. However, concerning changes in the culture of NHS trust in the UK, there is a lack of evidence for the application of lean thinking. From this end, six sigma as a new approach, less than 5% of participating hospitals are adopting six sigma methodology for managing process variability problems in the hospitals (Antony and Kumar, 2012b). It is indicating that the adoption of integrated LSS or LA in the supply chain practices is still in the early stage of research.

Based on the critical literature review, it is challenging to combine lean and agility throughout the one supply chain practices. However, companies tend to adopt a lean approach towards



the upstream supply chain and agility approaches towards the downstream supply chain activities or processes. In a case study research, Naylor et al. (1999) have demonstrated how agility and leanness have been combined within one supply chain to meet customer requirements.

This study also identified, most of the literature related to the theme of the topic combines two approaches of LSS or LA rather than LASS in the supply chain processes or practices. From this end, it is challenging to combine three approaches (lean, six sigma and agile) throughout the one supply chain. However, considering the demonstration of Naylor et al. (1999), there is a possibility to adopt three approaches in the different portions of one supply chain, such as in the upstream and downstream supply chain activities or processes. In this regard, integrated LSS can be adopted in the upstream supply chain and LA can be adopted in the downstream supply chain. The evidence from previous literature on integrated LSS adoption towards the upstream supply chain practices for various industries (Nauhria et al., 2009, Snee, 2010, Antony et al., 2017), and some evidence related to integrated leagile in the downstream supply chain (Nakandala and Lau, 2019, Naylor et al., 1999, Christopher and Towill, 2001a). For example, Naylor et al. (1999) have shown how a whole lean supply chain that incorporated agility in the downstream supply chain for positioning of the decoupling of the PC manufacturing industry. Nakandala and Lau (2019) indicate that the adoption of agility in the downstream supply chain activities could save time to maximize product freshness and taste, specifically in the context of the fresh food supply chain. Based on the above analysis, it can be assumed that the integrated LSS could be applicable in the upstream portion of the fresh food supply chain to reduce lead time and increase product value from suppliers to retailers or the whole seller's point of view. Therefore, it can claim that it is possible to adopt LASS in a different part of one supply chain.

## CHAPTER 5: FINDINGS AND DISCUSSION

### **5.1 Introduction**

The previous chapter outlined the analysis for the study. This chapter outlines the limitations and challenges of LASS in supply chain practices. This chapter outlines the key findings of this research, followed by the theoretical contributions of this research study. It also outlines the comparison of closely related papers in the literature. Finally, this chapter outlined the theoretical contributions and developed a conceptual framework for this research study.

### **5.2 Limitations and challenges of LASS in supply chain practices**

There are a significant number of limitations and challenges that are identified in the literature related to integrated Leagile/Leagility and LSS application in supply chain practices (Mason and Evans, 2015, Ugochukwu et al., 2012, Antony and Kumar, 2012a). Based on the review of the literature, the limitations and challenges have shown in the following Table 10 and Table 11.

Table 10: Limitations related to lean, agile and six sigma

limitations	Descriptions	References
<p>Lean</p> <ul style="list-style-type: none"> <li>• Lack of a lean principle/ Lack of awareness</li> <li>• Statistical and system analysis not valued</li> <li>• People issues</li> <li>• Fundamentally based on qualitative models</li> <li>• Fundamental shift of cultural issues</li> <li>• Poor training/coaching</li> <li>• Availability of resources</li> <li>• Lack of leadership</li> </ul>	<p>Lack of proper understanding of lean principles is a significant challenge to implement lean in SC</p> <p>Lack of statistical and system issue make it challenging to implement lean in SC</p> <p>Lack of training lack of trust in management makes it challenging to adopt lean in CS</p> <p>Many lean principles fundamentally based on qualitative models developed from years of experience</p>	<p>Zhou (2016a) Singh and Pandey (2015b)</p> <p>Al Owad et al. (2018b)</p> <p>Zhou (2016a)</p> <p>Zayati et al. (2012)</p> <p>Adebanjo et al. (2016b)</p> <p>Antony (2011a)</p>
<p>Agility</p> <ul style="list-style-type: none"> <li>• Difficult to measure</li> <li>• Lack of scalability</li> <li>• Unexpected changes</li> <li>• Fundamental shift of cultural issues</li> </ul>	<p>It is challenging to measure supply chain agility</p>	<p>Haq and Boddu (2017)</p> <p>Lotfi and Houshmand (2015) Li et al. (2008)</p>
<p>Six sigma</p> <ul style="list-style-type: none"> <li>• Cost intensive project</li> <li>• Top management commitment and involvement,</li> <li>• Implementations</li> <li>• lack of communication</li> <li>• lack of training and education and</li> <li>• limited resources</li> <li>• Fundamental shift of cultural issues</li> </ul>	<p>The high cost is a significant issue due to implement six sigma in the supply chain</p> <p>Lack of knowledge and expertise to encounter troubleshoot issues after implementation of the six sigma in SC</p> <p>Lack of trained people to implement</p>	<p>Kumar et al. (2011b) (Moosa and Sajid, 2010)</p> <p>Erbiyik and Saru (2015) Karthi et al. (2012)</p> <p>Kuvvetli et al. (2016)</p>

Table 11: Challenges related to lean, agile and six sigma in the supply chain

Challenges	Descriptions	References
<b>Lean</b> <ul style="list-style-type: none"> <li>Limited data collection opportunity</li> <li>Limited management support</li> <li>Limited training opportunity</li> </ul>	<p>Limited data collection opportunity makes it challenging to evaluate lean implementation in the SC</p> <p>Limited top management support makes it challenging to support lean adoption in SC</p> <p>Lack of business model and best practice for implementing lean in the supply chain</p>	<p>Zhou (2016a) Al Owad et al. (2018b) Adebanjo et al. (2016b)</p> <p>Singh and Pandey (2015b)</p> <p>Arif-Uz-Zaman and Nazmul Ahsan (2014)</p> <p>Singh and Pandey (2015b) Zhou (2016a)</p>
<b>Agility</b> <ul style="list-style-type: none"> <li>Limited scalability opportunity</li> <li>Unpredicted demand</li> <li>Short product life cycle</li> </ul>	<p>The agility concept makes it difficult to develop agility metrics</p>	<p>Gligor et al. (2015) Wilding et al. (2012) Nakandala and Lau (2019)</p>
<b>Six Sigma</b> <ul style="list-style-type: none"> <li>Limited management support</li> <li>Highly analytical method</li> <li>Limited opportunity for statistical training and development</li> </ul>	<p>Limited top management support makes it challenging to support lean adoption in SC</p> <p>Lack of trained people to implement six sigma in the supply chain</p> <p>Lack of knowledge and expertise to encounter troubleshoot issues after the implementation of six sigma</p>	<p>Kumar et al. (2011b) Erbiyik and Saru (2015)</p> <p>Moosa and Sajid (2010)</p> <p>Kuvvetli et al. (2016)</p> <p>(Karthi et al., 2012) (Meza and Jeong, 2013)</p>

### 5.3 The distribution of article based on systemic research

Evidence from the literature indicates that there are relatively few articles published in the area of LSS (40 articles), specifically for supply chain practices (Pheng et al., 2016, Taieb and Affes, 2013, Cai et al., 2009). More importantly, focusing on the systematic searching process, there are relatively limited articles found for the SSL approach in supply chain practices. The result of the systematic searches presents in Figure 12. Based on the systematic

search, 20 articles identified related to lean in the supply chain, 22 articles found related to six sigma in the supply chain, and 8 articles identified related to supply chain agility. Besides, 40 articles identified related to the integrated LSS, 14 articles on agility six sigma (SSA), and 9 articles related to lean and agility. The additional five articles are included using a general search. The general search has been conducted on the Google Scholar database. The key findings related to the systematic review of contemporary literature are outlined in Figure 12,

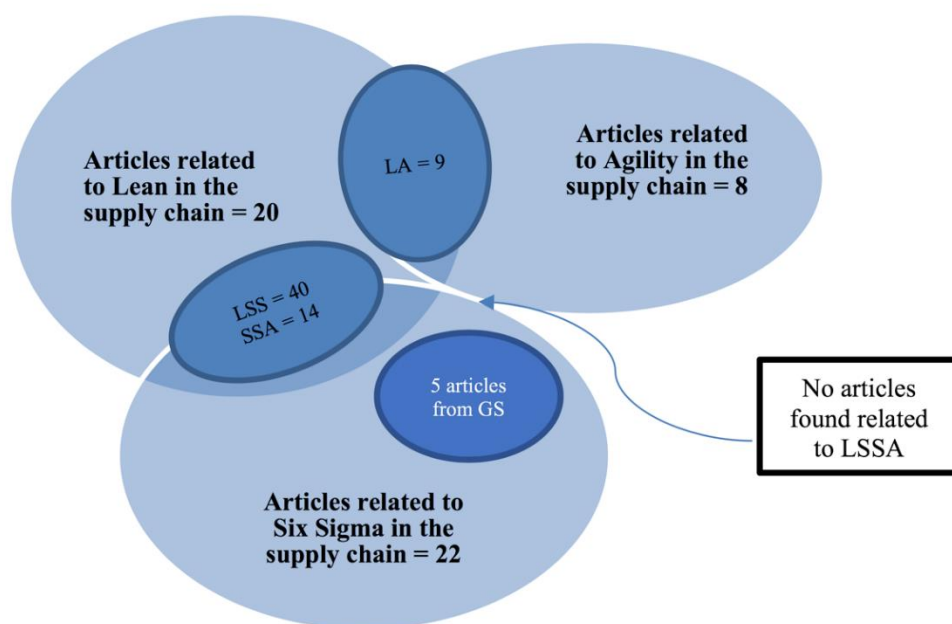


Figure 12: Article distribution related to the systematic searching process

## 5.4 Findings related to the systematic searches

The key findings related to the systematic search indicate that there are relatively limited articles that have been published related to the integrated approaches of six sigma agile (SSA) in the context of SC. There are relatively limited articles have been found related to the integrated approach of six sigma agile (SSA); therefore, further research is needed for investigating an integrated approach of six sigma and agile in the context of supply chain

management. It was found that very limited research has been carried out on integrated approaches of lean, six sigma and agility in the context of supply chain management. More importantly, until now, there were no articles published (from 2008 to date), on an integrated approach of LSSA in the context of supply chain management. This is the contribution of this research.

## **5.5 Findings related to the critical literature review**

This study clearly identified that most of the literature related to the broader topic of hybrid approaches is limited to studies of two approaches of LSS or LA rather than a complete hybrid approach of LASS in the supply chain context. It is evident from findings of challenges of hybrid approaches that it is more challenging to combine all three approaches (lean, six sigma and agile) in the supply chain across a range of industries. However, according to Naylor et al. (1999)'s work, there is a possibility to adopt three approaches in the different portions of one supply chain, such as different hybrid approaches in different parts of the supply chain (upstream and downstream) activities or processes. In this regard, integrated LSS can be adopted in the upstream supply chain and LA can be adopted in the downstream supply chain.

Based on the critical literature review, this research indicates that previous related literature focuses on the comprehensive analysis of lean six sigma (LSS), or lean agile philosophies within the supply chain context. Much of the literature identified integrated LSS or LA philosophies in the context of the supply chain. However, none of the other literature has critically reviewed integrated LSSA in the context of SCM by using a systematic literature review. In addition, based on the common tools of LSS as given in figure 4 of Chapter 2 of this study, there is a complementarity between lean and six sigma to deal effectively with the reduction of waste, cycle time, and non-value-added activities.

The synergies among three approaches have a shared focus on end-user value metrics such as reduction of time and cost, quality improvement initiatives in the supply chain processes. Thus a shared approach has the potential to add value to the customer more than what the individual approaches could make it alone. The challenges in a hybrid approach of LSSA extends beyond challenges in implementing individual approaches. A fundamental shift of stakeholder thinking and lack of top management support are significant challenges to improve performance in the supply chain.

Based on the scope of the study, supply chain performance measurement of contemporary literature is evaluated, benchmarked with the work of Neely et al. (1995). It defines a performance measurement system as a “set of metrics used to quantify the efficiency and effectiveness of actions” A metric is a piece of information with three distinctive features such as (1) verifiable quantitative or qualitative performance measure, that assesses what is happening; (2) measure assessed through a reference or target value; and (3) measure associated with consequences of being on or below or above target (Maestrini et al., 2017). This study extends the current knowledge base on the potential for integrating lean, agile and six sigma approaches in supply chain practice. Key findings from the critical literature review include:

1. While LSS and LA have been well researched in the context of supply chain practices, the hybrid approach of LASS has received relatively less attention.
2. Many research studies emphasise that all businesses in any supply chain must focus on end-user when integrating all three approaches.
3. Studies indicate potential benefits LA, LSS, SSA and LASS application in the manufacturing operation, automotive services, healthcare services, and the educational sector, including the agri-food supply chain sector.
4. Antony and Kumar (2012b) have shown the evidence of integrated LSS in National Health Services (NHS) in the UK; the applications of LSS reduce patient waiting time and improve the physical flow of material in hospitals.

Furthermore, a comparison of closely related papers in the literature is presented in the following Table 12. The following comparison is indicating that this study meets all the requirements (integrated LSS in SC, LA in SC, LASS in SC, SCM Limitations and Challenges) related to them of the study. However, other related papers are relatively lacking in these requirements. This is one of the significant contributions of this research.

Table 12: Comparison of closely related paper in the literature

References	Integrated LA in SC	Integrated LSS in SC	Integrated LASS in SC	Supply chain measurement	Limitations	Challenges
<b>This study</b>	✓	✓	✓	✓	✓	✓
Drohomeretski et al. (2014)	✓	x	x	✓	✓	x
<b>Antony and Kumar (2012b)</b>	✓	x	x	x	x	x
Hellman and Liu (2013)	x	x	x	✓	x	x
Kim et al. (2013)	x	✓	x	✓	x	x
Nakandala et al. (2016)	✓	x	x	✓	x	x
Snee (2010)	✓	x	x	x	✓	✓
Gligor et al. (2015)	x	✓	x	✓	x	✓
Eckstein et al. (2015)	x	✓	x	✓	✓	x
<b>Naylor et al. (1999)</b>	x	✓	x	✓	✓	✓
Arif-Uz-Zaman and Nazmul Ahsan (2014)	x	x	x	✓	x	x
Ustyugová (2013)	x	x	x	✓	x	x

## 5.6 Conceptual framework

In the supply chain management literature, the term framework has been used very frequently. A framework refers to the active employment of particular sets of recommendations (Soni and Kodali, 2012). However, there is a lack of consensus related to what framework is. According to Popper (1994), a framework is also a set of underlying assumptions or fundamental



principles on intellectual origin in which discussions and actions can proceed. If any concept of supply chain management is to be theoretically ‘designed and constructed’ then one would need to have the overall picture and structure for implementing, which is referred to as a framework (Samaranayake, 2005, Soni and Kodali, 2012). To this end, the following framework is indicating all businesses in any supply chain must focus on end-user; considering this philosophy, integrated LASS paradigms emphasise this point (Nakandala and Lau, 2019, Naylor et al., 1999). Based on a critical literature review of integrated approaches in the context of supply chain practices across a range of industries, a conceptual framework was proposed, identifying key themes including purpose, strategy and focus of each integration for various industries. The proposed conceptual framework is presented in Table 13.

Table 13: Conceptual framework for hybrid supply chain

Category	Lean supply chain (LSC)	Agile supply chain (ACS)	Six Sigma in the supply chain	Hybrid supply chain (HSC)
Purpose	Focus on eliminating waste or non-value-added activity; employ a continuous improvement process in the supply chain.	Capability to response in a changing environment and facilitate flexible accommodation for customer demand. Understand customer requirements by interfacing with customers and being adaptable to future change.	Focus on to remove or minimise potential variability from processes/products by using either a continuous improvement methodology or a design/redesign approach known as design for six sigma (DFSS)	Three characteristics such as 1) <i>use the market knowledge in the supply chain</i> 2) <i>integrate supply chain/ value stream/virtual corporation</i> and 3) <i>lead time compression</i> is indicating that both lean and agile can work together as a hybrid approach in supply chain practices.  Integrated LSS that extends customer satisfaction by reducing cost, improving quality, increasing process speed, and provide superior value to the stakeholders in the supply chain
Approach to manufacturing	Most suitable for manufacturing a traditional product with minimal innovation such as curtain rods or can openers	Most suitable for manufacturing innovative product such as cell phone, computer or fashions goods	Analyses defects to optimize process flow by using DMAIC / process-oriented approach	The strategic adoption of lean/agile, legality or leagile increases cost efficiency and time responsiveness in the manufacturing industries  Employ integrated LSS in Automotive manufacturing techniques.
Inventor strategy	Generates high turns and generate inventory throughout the supply chain	Make in response to customer demand	Six Sigma emphasizes eliminating variations or error for developing new metrics in the supply chain process.	Postpone product differentiation and minimise inventory, save storage cost and handling time
Integration	Integrate manufacturing, purchasing, quality, suppliers, and customers	Integrates marketing, engineering, distribution, and information system. The capability to adopt or response in a speedy manner in the changing marketplace	Advocates six sigma DMAIC methodology in manufacturing techniques Six Sigma focuses on to identify processes variation or defects by employing process control tools	The integration of LA or LSS creates value in supply chain practices. LSS increases the benefits in the supply chain practices because it integrates the human ( <i>such as leadership, customer focus, cultural change among others</i> ), process aspects ( <i>process capability, process management, statistical thinking</i> ) and process improvement

<b>Category</b>	<b>Lean supply chain (LSC)</b>	<b>Agile supply chain (ACS)</b>	<b>Six Sigma in the supply chain</b>	<b>Hybrid supply chain (HSC)</b>
Demand patterns	Predictable demand/ product with a long life cycle	Demand is unpredictable/ product with a short life cycle	Focuses on increasing customer satisfaction by emphasizes DMAIC methodology in the SC	The average demand for a product can be accurately forecasted, equally, meet the unexpected demand to satisfy customer
Lead time focus	Shorten lead-time as long as it does not increase the cost	Invest aggressively in ways to reduce lead times	Cycle time reduction and identified the cost of poor quality in the automotive subsidiary supply chain	Similar to LSC at the component level (shorten lead-time but not the expense level). Product level to be considered to accommodate customer requirements
Length of the product life cycle	Standard product has relatively long life cycle times, maximise performance and minimise cost	Innovative product have short life cycle times, design products to meet individual customer needs	Provide design/redesign approach known as design for six sigma (DFSS)	Use modular design in order to postpone product differentiation for as long as possible
Human resource	Empowered worker in terms in their functional department	Decentralized decision making, empowered individuals working in cross-functional teams	Educate SS and empowered workers to enlarge cross-functional teams.	Empowered individuals working in teams in their functional departments
End-User Focus	All businesses in any supply chain must focus on end-user; lean paradigm emphasises this point	All businesses in any supply chain must focus on end-user; agility paradigm emphasises this point	All businesses in any supply chain must focus on end-user; six sigma paradigm emphasises this point	All businesses in any supply chain must focus on end-user; all lean, agile six sigma paradigms emphasize this point

## 5.6 Potential benefits of integrating LASS in the supply chain

Studies indicate possible benefits of LSS or LA application in the manufacturing operation, automotive services, healthcare services, and the educational sector, including the food supply chain sector (Albliwi et al., 2015, Chakraborty and Leyer, 2013). The integrated LSS application improves bottom-line results in the manufacturing operations, such as cost reduction, quality improvement (Govindan and Hasanagic, 2018, Habidin and Yusof, 2012, Kuvvetli et al., 2016). Similarly, this research indicates that the adoption of integrated LASS will have similar benefits in the supply chain practices (sources, procurement, and distribution). Consequently, supply chain performance will be improved by overcoming limitations and challenges in the supply chain. The following Table 14 indicates such benefits of using the integrated approach in the supply chain practices.

Table 14: Potential benefits of integrating LASS in the supply chain

<b>Benefits</b>	<b>References</b>
Reduce cost (cost of poor quality/production cost)	Albliwi et al. (2015) Abu Bakar et al. (2015) Adebanjo et al. (2016b) Nauhria et al. (2009)
Reduce all kind of wastes	Pillai et al. (2012) Psychogios and Tsironis (2012) Meza and Jeong (2013) Zhou (2016a)
Increase customer satisfaction	Timans et al. (2012) Nauhria et al. (2009)
Reduce cycle times/ lead time	Antony and Kumar (2012b) Antony et al. (2016)
Reduce in machine breakdown time/ defects	Cheng and Chang (2012) Habidin and Yusof (2012)
Reduce inventory	Mustafa Kamal and Irani (2014) Psychogios and Tsironis (2012) Snee (2010)
Improve quality	Timans et al. (2012) Lotfi and Houshmand (2015) Mackelprang and Nair (2010)
Increase bottom-line results in the SC	Hellman and Liu (2013) Kumar et al. (2011b)
Enhance business sustainability	Kuvvetli et al. (2016) Moosa and Sajid (2010) Gligor et al. (2015)

## 5.7 Research contribution

This study contributes to the existing literature by critically reviewing the current literature on hybrid approaches of lean, agile, and six sigma philosophies, emphasising challenges, limitations and benefits of integrated approaches in the context of supply chain management for various industries. Based on a critical literature review of integrated approaches in the

context of supply chain practices across a range of industries, this study proposed a conceptual framework, which in the bases of integrating three approaches in different portions (upstream and downstream) of one supply chain. This study also explores challenges, opportunities and limitations of integrated LA and LSS adoption in the supply chain and identified possible benefits such as cost reduction, saving time and improve quality in supply chain practices. The lack of top management support, lack of expertise, a fundamental shift of stakeholders thinking, among others, are highlighting limitations and challenges for implementing such integrated approaches in the supply chain. This research also provides an in-depth understanding related to the hybrid approach of LSSA improvement philosophy from the end-users perspective. The insight of end-user philosophy is a novel contribution of this study to the body of knowledge.

**Contribution to knowledge:** This study contributed a critical literature review of integrated approaches of lean, agile and six sigma philosophies in the context of supply chain practices across a range of industries and proposed a conceptual framework. It identified key themes, including purpose, strategy and focus of each integration for various industries in the context of supply chain management.

**Contribution to society:** This study could potentially add to meet better customer expectations of society by improving efficiency in terms of saving cost and time and improving performance quality in the supply chain practices.

**Potential policy implication:** The LASS improvement philosophy may contribute as guidance to managers and practitioners for improving performance in the supply chain management.

## CHAPTER 6: CONCLUSION AND FUTURE RESEARCH DIRECTIONS

### **6.1 Introduction**

The previous chapter outlined the key findings of this research. This chapter outlines the identification of the originality of this research, such as the application of LSSA philosophy in the context of supply chain management. This chapter also outlines the limitations and future research directions of this study.

### **6.2 Conclusion**

This study critically reviewed the literature related to integrated approaches of lean, agile, and six sigma philosophies in the supply chain practices, primarily to gain insight into current models and strategies applied in the supply chain practices for various industries. It offers desktop research based on a literature review. Considering the scope of the study, this research addressed a central research question and three sub research questions to achieve the research objective. The central research question is, to what extent are the current integrated approach of lean, agile and six sigma influencing supply chain performances?

This study looks at key definitions of performance measurement and improvement aspects within the broader adoption of integrated approaches in supply chain management. For example, it is noted that it is vital to integrate the effectiveness and efficiency into the supply chain performance measurement system. Supply chain performance and improvement using hybrid approaches in the supply chain management context. The study also looks at the

challenges, limitations and identified potential benefits of an integrated approach of LASS application in the supply chain practices. A fundamental shift of stakeholder thinking is a critical limitation for such integrated approaches in the supply chain. Based on the literature review, there is a relatively limited article found related to integrated SSA adoption in the supply chain process or activity. This research uses a systematic literature review as a research methodology. This research adopted a three-stage review method. A critical literature review conducted on 118 peer-reviewed articles from 40 different journals.

Based on the critical literature review, it is challenging to combine lean, and agility throughout the one supply chain processes/activities, but companies tend to adopt a lean approach towards the upstream supply chain and agility approaches towards the downstream supply chain activities or processes. Based on the analysis of this study, it can be assumed that the integrated LSS could be applicable in the upstream portion of one supply chain and agile can be applied downstream portion of the same supply chain. Therefore, it can claim that it is possible to adopt LASS in a different part (upstream and downstream) of one supply chain.

This study indicates a growing need for integrating these approaches in the supply chain. The research interest related to these integrated philosophies has been received increasing attention in academia and business. The popularity of the LSS improvement philosophy is increasingly receiving attention in supply chain management. A broader range of research has been carried out on these approaches for the manufacturing and services industry perspective. Many services industry is adopting LSS philosophy as a popular business model.

Based on a critical literature review, this study developed a conceptual framework, which in the bases of integrating three approaches in different portions (upstream and downstream) of one supply chain practices. The originality of this research is to explore limitations and challenges to identify the benefits of cost reduction, time efficiency and quality improvement

in supply chain practices. The application of these philosophies in the supply chain enables improvements such as cost reduction, quality improvement, saving time, improving core results and creating value for customers and stakeholders. The conclusion included the key finding of the thesis. Conclusions from the research findings include:

1. The originality of this research is the identification of current practices of LASS by integrating LA in downstream SC and LSS in upstream SC, which could lead to a range of benefits (cost reduction, all kinds of wastes reduction, increases customer satisfaction, lead time reduction) in supply chain practices.
2. The application of such philosophies (LASS) in the supply chain enables improvements such as cost reduction, quality improvement, saving time, improving core results, and creating value for customers and stakeholders.
3. This research addressed relatively unattended areas within broader supply chain management. The implication of this study may help supply chain managers to use integrated philosophy to improve their supply chain practices/ performance.
4. This research provided the current limitations of the research and insights for future research directions.

This research addressed relatively unattended research areas within broader supply chain management. The implication of this study may help supply chain managers to use integrated philosophy to improve their supply chain performance. This research claims the insight of end-user philosophy, which is a novel addition of this study to the body of knowledge. Furthermore, this study offer integrated leagile and LSS could be applicable in the various portion (Br et al.) of one supply chain. Thus, this research is unique.

### **6.3 Limitations and future research**

Limitations inherent in any single publication can be addressed through future research. This research critically reviewed the literature on current hybrid approaches of lean, agile and six sigma philosophies in the context of supply chain management using a systematic review methodology. However, a future empirical study on these approaches might be useful for specific industry perspectives. This study covers literature from 2008 to date only. Future



research might, for example, collect data for 20 years. There is a need for more research to extend this knowledge, create greater confidence in the findings, and find further insights.

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## **APPENDIXES**

**Appendix 1** Similarities and differences between a SLR and TLR

**Appendix 2** Systematic searching process

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## Appendix 1: Similarities and differences between a SLR and TLR

Criteria	Systematic review	Traditional review
Questions	Focused on a single question	Not necessarily focused on the single question, but may describe an overview
Protocol	A peer review protocol or plan is included	No protocol is included
Background	Both provide summaries of the available literature on a topic	Both provide summaries of the available literature on a topic
Objectives	Clear objectives are identified	Objectives may or may not be identified
Inclusion and exclusion criteria	Criteria stated before the review conducted	Criteria not specified
Search strategy	A comprehensive search conducted in a systematic way	Strategy not explicitly stated
The process of selecting articles	Usually clear and explicit	Not described in a literature review
The process of evaluating articles	Comprehensive evaluation of the study quality	Evaluation of the study quality may or may not be included
The process of extracting relevant information	Usually clear and specific	Not clear and explicit
Rules of data synthesis	Clear summaries of studies based on high-quality evidence	Summary based on studies where the quality of the articles may not be specified; may also be influenced by the reviewer's theories, needs, and assumptions
Discussion	Written by an expert or group of experts, with detailed and well-grounded knowledge of the issues	Written by an expert or group of experts, with detailed and well-grounded knowledge of the issues

## Appendix 2: Systematic searching process

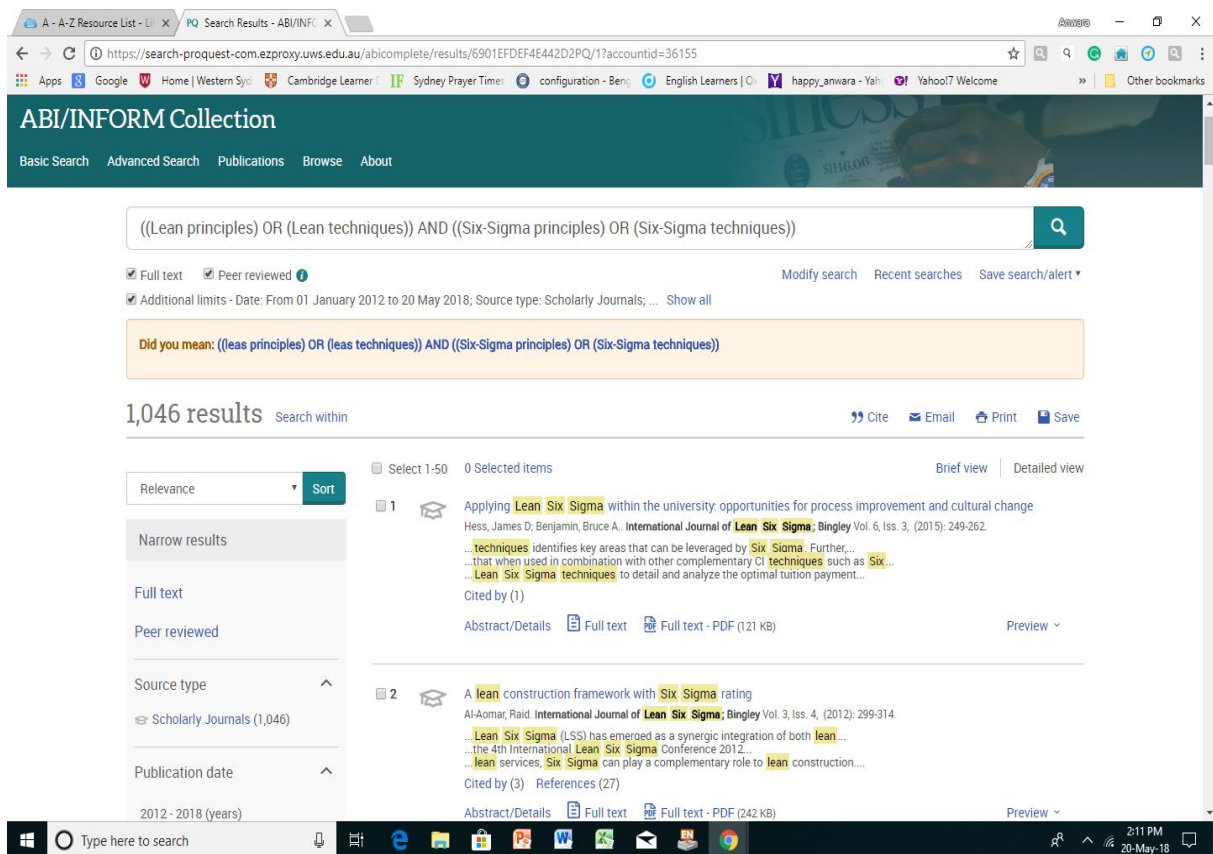
Articles search as at 20 May 2018

**Full text, Peer reviewed, Time limit: 1/1/2012 to date – applied for all search**

### a. Lean and Six Sigma

**Search String 1:** ((Lean principles) OR (Lean techniques)) AND ((Six Sigma principles) OR (Six Sigma techniques))

**Search Result 1:** Resulted in 1046 articles



ABI/INFORM Collection

Basic Search Advanced Search Publications Browse About

Search String: ((Lean principles) OR (Lean techniques)) AND ((Six Sigma principles) OR (Six Sigma techniques))

Full text Peer reviewed Additional limits - Date: From 01 January 2012 to 20 May 2018; Source type: Scholarly Journals; ... Show all

Did you mean: ((lean principles) OR (lean techniques)) AND ((Six Sigma principles) OR (Six Sigma techniques))

1,046 results Search within

Relevance Sort

Narrow results

Full text

Peer reviewed

Source type

Scholarly Journals (1,046)

Publication date

2012 - 2018 (years)

1 Applying **Lean Six Sigma** within the university: opportunities for process improvement and cultural change  
Hess, James D; Benjamin, Bruce A. *International Journal of Lean Six Sigma*; Bingley Vol. 6, Iss. 3, (2015): 249-262.  
... **techniques** identifies key areas that can be leveraged by **Six Sigma**. Further...  
... that when used in combination with other complementary CI **techniques** such as **Six**...  
... **Lean Six Sigma techniques** to detail and analyze the optimal tuition payment...  
Cited by (1)  
Abstract/Details Full text Full text - PDF (121 KB) Preview

2 A **lean** construction framework with **Six Sigma** rating  
Al-Aomar, Raid. *International Journal of Lean Six Sigma*; Bingley Vol. 3, Iss. 4, (2012): 299-314.  
... **Lean Six Sigma** (LSS) has emerged as a synergic integration of both **lean**...  
... the 4th International **Lean Six Sigma** Conference 2012...  
... **lean** services, **Six Sigma** can play a complementary role to **lean** construction....  
Cited by (3) References (27)  
Abstract/Details Full text Full text - PDF (242 KB) Preview

**Search String 2:** (((Lean principles) OR (Lean techniques)) AND ((Six Sigma principles) OR (Six Sigma techniques))) AND ab(((Lean) AND (Six Sigma)))

**Search Result 2:** Resulted in 121 articles

ProQuest

All databases | Change databases

ABI/INFORM Collection

Basic Search | Advanced Search | Publications | Browse | About

(((Lean principles) OR (Lean techniques)) AND ((Six-Sigma principles) OR (Six-Sigma techniques))) AND ab(((lean) AND (Six-Sigma)))

Full text Peer reviewed

Additional limits - Date: From 01 January 2012 to 20 May 2018; Source type: Scholarly Journals; ... Show all

Did you mean: (((leas principles) OR (leas techniques)) AND ((Six-Sigma principles) OR (Six-Sigma techniques))) AND ab(((leas) AND (Six-Sigma)))

121 results Search within

Cite Email Print Save

Select 1-50 0 Selected items

Brief view Detailed view

Relevance Sort

Narrow results

Full text

Peer reviewed

Source type

1 Applying **Lean Six Sigma** within the university: opportunities for process improvement and cultural change  
Hess, James D; Benjamin, Bruce A. *International Journal of Lean Six Sigma*; Bingley Vol. 6, Iss. 3, (2015): 249-262.  
...techniques identifies key areas that can be leveraged by **Six Sigma**. Further, ...  
...that when used in combination with other complementary CI techniques such as **Six**...  
...**Lean Six Sigma techniques** to detail and analyze the optimal tuition payment...  
Cited by (1)  
Abstract/Details Full text Full text - PDF (121 KB) Preview

2 Investigating the green impact of **Lean, Six Sigma** and **Lean Six Sigma**: A systematic literature review

## b. Lean AND Agility

**Search String 1:** ((Lean principles) OR (Lean techniques)) AND ((Agility) OR (responsiveness))

**Search Result 1:** Resulted in 1257 articles

The screenshot shows a ProQuest search results page. The search query is entered in the search bar: ((Lean principles) OR (Lean techniques)) AND ((Agility) OR (Responsiveness)). Below the search bar, there are filters for 'Full text' and 'Peer reviewed', and a date range from 01 January 2012 to 20 May 2018. A suggestion box below the search bar reads: 'Did you mean: ((leas principles) OR (leas techniques)) AND ((Agility) OR (Responsiveness))'. The results section shows '1,257 results'. On the left, there is a sidebar with 'Narrow results' including 'Full text', 'Peer reviewed', and 'Source type' (Scholarly Journals (1,257)). The main results list shows two items:

1. **Leanness and agility: a comparative theoretical view**  
Eltawy, Nesrine; Gallea, David. *Industrial Management & Data Systems*, Wembley Vol. 117, Iss. 1, (2017): 149-165.  
...paper seeks to provide a deep understanding for **lean** and **agility** philosophies as...  
...**lean**, and **agility**, and **lean** and/or **agility**. The systematic review on **lean**...  
Abstract/Details | Full text | Full text - PDF (315 KB) | Preview
2. **A new approach for estimating leagile decoupling point using data envelopment analysis**  
Shahin, Arash; Gunasekaran, Angappa; Khalili, Azam; Shirouyehzad, Hadi. *Assembly Automation*, Bedford Vol. 36, Iss. 3, (2016): 233-245.  
...(2008). **Principles and Techniques of Lean Six Sigma**, Arkan Danesh...  
...**principles** of leagile theory can be used for distinguishing **Lean** and agile...  
...**principles** (Chan and Kumar, 2009). Although in a **Lean** supply chain,...

**Search String 2:** (((Lean principles) OR (Lean techniques)) AND ((Agility) OR (responsiveness))) AND ab(((Lean) AND (agility)))

**Search Result 2:** Resulted in 17 articles

The screenshot shows the ProQuest ABI/INFORM Collection search results page. The search string entered is: (((Lean principles) OR (Lean techniques)) AND ((Agility) OR (Responsiveness))) AND ab(((lean) AND (agility))). The results are sorted by Relevance and show 17 results. The first two results are displayed:

- 1** Leanness and **agility**: a comparative theoretical view  
Eltaay, Nesrine; Galleir, David. *Industrial Management & Data Systems*; Wembley Vol. 117, Iss. 1, (2017): 149-165.  
...paper seeks to provide a deep understanding for **lean** and **agility** philosophies as...  
...**lean**, and **agility**, and **lean** and/or **agility**. The systematic review on **lean**...  
Abstract/Details Full text Full text - PDF (315 KB) Preview
- 2** **Lean** production as promoter of thinkers to achieve companies' **agility**  
Alves, Anabela C; Dinis-Carvalho, José; Sousa, Rui M. *The Learning Organization*; Bradford Vol. 19, Iss. 3, (2012): 219-237.  
...to guide companies so they can take advantage of LP **Lean** thinking has five main...  
...is all about the system and not only about tools and **techniques**, calling this...  
...application of the **Lean Principles** to the services. Toyota education model...

The interface includes a search bar, filters for Full text, Peer reviewed, and Source type (Scholarly Journals (17)), and options to Cite, Email, Print, or Save the results.

## c. Six sigma AND Agility

**Search String 1:** ((Six Sigma principles) OR (Six Sigma techniques)) AND ((Agility) OR (responsiveness))

**Search Result 1:** Resulted in 374 articles

ProQuest  
All databases | Change databases  
ABI/INFORM Collection  
Basic Search | Advanced Search | Publications | Browse | About

Search Results - ABI/INFORM  
https://search-proquest-com.ezproxy.uws.edu.au/abicomplete/results/68B93597A8C499EPQ/1?accountid=36155

Search: ((six-sigma principles) OR (six-sigma techniques)) AND ((Agility) OR (Responsiveness))

Full text | Peer reviewed | Additional limits - Date: From 01 January 2012 to 20 May 2018; Source type: Scholarly Journals; ... Show all

374 results | Search within | Cite | Email | Print | Save

Relevance | Sort | Select 1-50 | 0 Selected items | Brief view | Detailed view

Narrow results

- Full text
- Peer reviewed
- Source type  
Scholarly Journals (374)
- Publication date

1 Factors in the Path From Lean to Patient Safety: Six Sigma, Goal Specificity and Responsiveness Capability  
McFadden, Kathleen L; Lee, Jung Young; Gowen, Charles, III. *The Quality Management Journal; Milwaukee* Vol. 22, Iss. 4, (2015): 37-53.5.  
...largely attributed to increases in patient responsiveness, while Six Sigma and...  
...goal setting, healthcare, lean, patient safety, responsiveness capability, Six...  
...that Six Sigma and goal specificity are critical in linking lean to patient...

Images (4)

Cited by (2) | References (89)

Abstract/Details | Full text | Full text - PDF (3 MB) | Preview

Type here to search | 2:18 PM 20-May-18



**Search String 1:** (((Six Sigma principles) OR (Six Sigma techniques)) AND ((Agility) OR (responsiveness))) AND ab((((Six Sigma) OR (Agility))))

**Search Result 1:** Resulted in 52 articles

ProQuest  
All databases | Change databases  
ABI/INFORM Collection  
Basic Search | Advanced Search | Publications | Browse | About

Search results for: (((six-sigma principles) OR (six-sigma techniques)) AND ((Agility) OR (Responsiveness))) AND ab((((Six-Sigma) OR (Agility))))

52 results

Full text | Peer reviewed | Additional limits - Date: From 01 January 2012 to 20 May 2018; Source type: Scholarly Journals; ... Show all

Modify search | Recent searches | Save search/alert

52 results | Search within | Cite | Email | Print | Save

Select 1-50 | 0 Selected items | Brief view | Detailed view

Relevance | Sort

Narrow results

Full text

Peer reviewed

Source type

Scholarly Journals (52)

Publication date

1 Factors in the Path From Lean to Patient Safety: Six Sigma, Goal Specificity and Responsiveness Capability  
McFadden, Kathleen L; Lee, Jung Young; Gowen, Charles, III. The Quality Management Journal; Milwaukee Vol. 22, Iss. 4, (2015): 37-53.5.  
...largely attributed to increases in patient responsiveness, while Six Sigma and...  
...goal setting, healthcare, lean, patient safety, responsiveness capability, Six...  
...that Six Sigma and goal specificity are critical in linking lean to patient...

Images (4)

Cited by (2) | References (89)

Abstract/Details | Full text | Full text - PDF (3 MB) | Preview

## d. Lean AND Six Sigma AND Agility AND Supply Chain Performance

**Search String 1:** (((Lean principles) OR (Lean techniques)) AND ((Six Sigma principles) OR (Six Sigma techniques))) AND ((Agility) OR (responsiveness))) AND (supply chain performance)

**Search Result 1:** Resulted in 213 articles

ProQuest  
All databases | Change databases  
ABI/INFORM Collection  
Basic Search Advanced Search Publications Browse About

(((Lean principles) OR (Lean techniques)) AND ((six-sigma principles) OR (Six Sigma Techniques))) AND ((Agility) OR (Responsiveness))) AND (Supply Chain Performance)

Full text Peer reviewed  
Additional limits - Date: From 01 January 2012 to 20 May 2018; Source type: Scholarly Journals; ... Show all

Did you mean: (((lean principles) OR (lean techniques)) AND ((six-sigma principles) OR (Six Sigma Techniques))) AND ((Agility) OR (Responsiveness))) AND (Supply chains Performance)

213 results Search within

Relevance Sort  
Narrow results  
Full text  
Peer reviewed

Select 1-50 0 Selected items  
Brief view Detailed view

1 Investigating the green impact of **Lean**, **Six Sigma** and **Lean Six Sigma**: A systematic literature review  
Chugani, Nashmi, Kumar, Vikas, Garza-Reyes, Jose Arturo, Rocha-Lona, Luis, Upadhyay, Arvind. *International Journal of Lean Six Sigma*, Bingley Vol. 8, Iss. 1, (2017): 7-32.  
...systems approach. Another **technique** for applying **Lean Six Sigma** is the...  
...performance while implementing **Lean Six Sigma**. GLSS is an emerging concept that...  
...Lean and **Six Sigma** have **principles** focused on solving problems of quality...  
Cited by (1)  
Abstract/Details Full text Full text - PDF (496 KB) Preview

**Search String 2:** (((Lean principles) OR (Lean techniques)) AND ((Six Sigma principles) OR (Six Sigma techniques)) AND ((Agility) OR (responsiveness))) AND (supply chain performance)) AND ab((((Lean) AND (Six Sigma)) OR ((Agility) AND (supply chain performance))))))

**Search Result:** Resulted in 19 articles

ProQuest  
All databases | Change databases  
ABI/INFORM Collection  
Basic Search Advanced Search Publications Browse About

(((Lean principles) OR (Lean techniques)) AND ((Six-sigma principles) OR (Six Sigma Techniques)) AND ((Agility) OR (Responsiveness))) AND (Supply Chain Performance)) AND ab((((Lean) AND (Six-Sigma)) OR ((Agility) AND (Supply chain performance))))))

☒ Full text ☒ Peer reviewed [Modify search](#) [Recent searches](#) [Save search/alert](#)

☒ Additional limits - Date: From 01 January 2012 to 20 May 2018; Source type: Scholarly Journals; ... [Show all](#)

**Did you mean:** (((lean principles) OR (lean techniques)) AND ((six-sigma principles) OR (Six Sigma Techniques)) AND ((Agility) OR (Responsiveness))) AND (Supply chains Performance)) AND ab((((lean) AND (Six-Sigma)) OR ((Agility) AND (Supply chains performance))))))

**19 results** [Search within](#) [Cite](#) [Email](#) [Print](#) [Save](#)

Relevance [Sort](#) [Select 1-19](#) [0 Selected Items](#) [Brief view](#) [Detailed view](#)

**Narrow results**

[Full text](#)  
[Peer reviewed](#)

**1** **Investigating the green impact of Lean, Six Sigma and Lean Six Sigma. A systematic literature review**  
Chugani, Nashmi, Kumar, Vikas; Garza-Reyes, Jose Arturo; Rocha-Lona, Luis; Upadhyay, Arvind. *International Journal of Lean Six Sigma*; Bingley Vol. 8, Iss. 1, (2017); 7-32.  
...systems approach. Another technique for applying Lean Six Sigma is the...  
...performance while implementing Lean Six Sigma. GLSS is an emerging concept that...  
...Lean and Six Sigma have principles focused on solving problems of quality...  
Cited by (1)  
[Abstract/Details](#) [Full text](#) [Full text - PDF \(496 KB\)](#) [Preview](#)