LEAN INITIATIVES IN SMALL AND MEDIUM-SIZED ENTERPRISES

Ph.D. Thesis

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DECLARATION

I, **Vinod Yadav**, declare that this thesis titled, "**Lean Initiatives in Small and Medium-sized Enterprises**" and the work presented in it, are my own. I confirm that:

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- Where I have consulted the published work of others, this is always clearly attributed.
- Where I have quoted from the work of others, the source is always given. With the exception of such quotations, this thesis is entirely my own work.
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- Where the thesis is based on work done by myself, jointly with others, I have made clear exactly what was done by others and what I have contributed myself.

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CERTIFICATE

This is to certify that the thesis entitled **"Lean Initiatives in Small and Medium-sized Enterprises"** being submitted by **Vinod Yadav (2015RME9048)** is a bonafide research work carried out under our supervision and guidance in fulfilment of the requirement for the award of the degree of **Doctor of Philosophy** in the Department of Mechanical Engineering, Malaviya National Institute of Technology, Jaipur, India. The matter embodied in this thesis is original and has not been submitted to any other University or Institute for the award of any other degree.

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ABSTRACT

The roots of lean manufacturing lie in the Toyota Production System which was launched and executed by Toyota (Krafcik, 1988). Realising the enormous benefits, lean manufacturing was adopted by other automotive manufacturers across the world. The application of lean, however, is not limited to automobile sector only; instead, other sectors such as manufacturing, service, construction, hospitality, and process industries have also been benefited from the implementation of lean (Suárez-Barraza *et al*. 2012; Bhamu and Sangwan 2014). These sectors have witnessed the positive impact of lean on the operational, financial, social and environmental performance of the organisation (Shah and Ward 2007; Fullerton and Wempe 2009; Hofer *et al*. 2012). Previous research in this field has focused upon the large enterprises. However, its application in Small and Medium Enterprises (SMEs) has been seldom studied so far.

Academicians and practitioners have suggested that the application of lean principles and philosophies is not limited to large enterprises (LEs), but can also be adopted in SMEs. Owing to the basic principles of lean: the elimination of waste, value enhancement, and customer satisfaction, being generic, lean should be applicable to SMEs. It is argued that as SMEs often have higher flexibility, faster decision making and quicker response to customers, they create a positive environment for lean implementation.

After the comprehensive literature review, some research gaps were identified and accordingly three research objectives were selected. These objectives are: to explore lean implementation issues in SMEs, to establish the relationship between lean practices and performance improvement in SMEs, and to develop a lean implementation framework for SMEs. Research hypotheses were developed to address the research objectives and further to test these hypotheses a survey instrument was constructed. The survey companies were randomly identified from the database of the Confederation of Indian Industries (CII).

From the survey result the significant reasons of lean implementation in SMEs, critical success factors of lean implementation in SMEs and barriers to implement lean in SMEs were identified. Further, structural equation modelling approach is used to test the impact of lean thinking on the operational and financial performance of SMEs. The results confirmed the perception that rather than a full lean concept, SMEs are adopting lean in a partial manner, i.e., implementing a limited number of practices. The findings supported the statement 'the application of lean practices is positively associated with the operational performance of SMEs.' A major finding of the study is the mediating role of the operational measures in the relationship between the partial lean adoption and the economic performance. It implies that lean adoption not only improves that operational measures but also positively affects the financial measures.

Further four case studies were carried out because four cases together will combine to lead to a better understanding of lean adoption in Indian SMEs and will help in interpretation of proposition formulated in this study. The case findings also support the survey results; this validates our results. After the assessment of case studies, the barriers to implement lean (LIBs) in SMEs were identified and modelled using ISM approach.

Lastly, a lean implementation framework for SMEs was developed. Along with lean practices and performances, it also deals with lean implementation barriers (LIBs). Therefore, the framework not only demonstrate the way of implementing lean practices in the organisations but also helps in managing the LIBs. Hence, all the research objectives were achieved and limitations and directions for future research were proposed.

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Chapter 1

Introduction

1.1 Introduction

From last two decades, the production models and systems have been subjected to evolution. As a consequence of which, the companies are facing increased burden from customers and opponents to supply high quality goods with low cost in shortest lead time. Competitive market conditions have marked the rise of lean thinking principles which enables companies to withstand competition by means of adopting waste elimination and value addition approaches (Kumar *et al.,* 2006). As waste is eliminated, quality improves while production time and cost are reduced. Lean manufacturing assist in the identification and steady elimination of wastes.

Lean principles emphasise system-level optimization, where the emphasis is on integration and how the parts work together as a whole, rather than on individual performance and excellence of any one feature or element. There are five key principles of lean thinking (Womack and Jones 1996) i.e. value, value stream, flow, pull and perfection.

After successful implementation in Toyota, lean was adopted by European and American automobile manufacturers (Womack *et al.* 1990). Subsequently, it was adopted in other industrial sectors such as aerospace (Psychogios and Tsironis 2012; Jurado and Fuentes 2014), construction (Liu *et al.* 2013; Vinodh *et al.* 2014;), fabrication and metal processing (Demeter and Matyusz 2010), food processing (Rashid *et al.* 2010; Dora *et al.* 2015; Vlachos 2015), healthcare (Hicks *et al.* 2016), telecommunication and IT (Psychogios *et al.* 2012), service (Radnor and Johnston 2013) and textiles (Hodge *et al.* 2011). The successful application of lean across industries with diverse characteristics has supported the claim by its proponents that lean is a universal production system (Billesbach 1994; Womack and Jones 1996). Researchers and practitioners (Chaplin *et al.* 2016; Fullerton and Wempe 2009; Shah and Ward 2003) have reported the positive impacts of lean on operational, financial, social and environmental performance, ultimately leading to enhanced customer satisfaction.

Lean as a concept has evolved over time, and will continue to do so (Hines *et al.* 2004). Its application, however, has largely been limited to large enterprises for the elimination of waste, improved quality and service, reduced total cost and lead time. The application of lean to SMEs, till now, remains meagre. Such limited application raises questions about its suitability to SMEs. This study attempts to address this question.

It is believed that SMEs are the backbone of the industrial and economic growth of a nation and also make a significant contribution to employment creation (Singh 2011; Singh *et al.* 2010). SMEs are also recognised as important players in large supply chain networks. Increased competitiveness and thin profit margins compel SMEs to produce goods with high quality, variety and flexibility, and faster deliveries and lower cost. Unfortunately, they often suffer from low productivity, poor quality, long product development lead times, high inventory, low flexibility, and ultimately poor organizational performance (Gnanaraj *et al.* 2012; Mathur *et al.* 2012; Thakkar *et al.* 2013; Chaplin *et al.* 2016). Therefore, it is imperative to focus on the improvement of SMEs' performance. Ates *et al.* (2013) suggest that SMEs can no longer survive without using world class manufacturing processes and management practices. To gain and sustain a competitive advantage and to deal with other problems, it is essential to apply philosophies such as lean thinking throughout supply chains (Jasti and Kodali 2015). The implementation of lean, however, is a challenging task in SMEs.

Researchers (Achanga *et al.* 2006; Timans *et al.* 2012; Dora *et al.* 2013; Dora *et al.* 2015; Hu *et al.* 2015) have argued that lean implementation requires good leadership, management skills, knowledge, financial capability and learning skills. As most SMEs lack these skills, (Singh *et al.* 2005; Gnanaraj *et al.* 2012; Mathur *et al.* 2012; Thakkar *et al.* 2013; Chaplin *et al.* 2016) lean implementation in SMEs is challenging. Although positive outcomes have been gained from some reported implementations, such evidence is scarce. Hence, there is a need for further research (Vinodh *et al.* 2014; Vlachos 2015; Dora *et al.* 2015; Alaskari *et al.* 2016; Manfredsson 2016; Thomas *et al.* 2016). Some SMEs have only implemented lean thinking in a partial fashion (Bamford *et al.* 2015; Chaplin *et al.* 2016) and although a few researchers have focused on lean implementation in SMEs, a framework for its implementation is absent in the literature.

Academicians and practitioners have suggested that the application of lean principles and philosophies is not limited to large enterprises (LEs), but can also be adopted in SMEs. Owing to the basic principles of lean: the elimination of waste, value enhancement, and customer satisfaction, being generic, lean should be applicable to SMEs. It is argued that as SMEs often have higher flexibility, faster decision making and quicker response to customers, they create a positive environment for lean implementation (Chaplin *et al*. 2016).

Moreover, adoption of lean thinking in India has been started very recently. Hence, the status of lean implementation in India is still ambiguous. Therefore, it is uncertain whether the SMEs in India are enthusiastic about implementation of lean, or not. Extant literature review confirms that until now no attempt has been made to investigate the status of lean thinking in Indian SMEs. Present study is an attempt to fill this gap in research and will examine various aspects of lean implementation in SME sector of India.

1.2 Research objectives

It is believed that SMEs are the backbone of industrial and economic growth of a nation and it contributes to employment creation. Despite the fact that SMEs contribute a lot to the industrial and economic growth of the nation and also plays a crucial role to the supply chain of large enterprises (Singh 2011; Singh *et al.* 2010); this sector is often ignored in research arena as far as adoption of lean is concerned. Although, the numerous studies have reported the tremendous benefits of lean adoption in large enterprises (Shah and Ward 2003; Shah and Ward 2007; Belekoukias et al. 2014; Bevilacqua et al. 2017), a lot of scepticism still remains regarding its impact in SMEs. The benefits of the same, however, still need to be assessed in SMEs. This topic has recently gained attention in a developing country like India, where SMEs account 45 percent of entire exports and 45% to the total manufacturing output and provides employment to over 80 million persons (MSME 16).

Generally, large enterprises adopt full lean in an integral way while on the other hand SMEs cannot do so (Chaplin *et al.* 2016). The SME sector implements a limited number of practices or adopts lean with the piecemeal approach (Filho *et al.* 2016). Only a few studies reported the successful adoption of lean in SMEs (Hu *et al.* 2015). Therefore, there is a need of explanation and analysis of limited or partial implementation of lean thinking in SMEs and it is required to explore the status and future prospects of lean thinking implementation in SMEs, the following objectives have been chosen for the current research work:

- To explore lean implementation issues in SMEs
- To establish the relationship between lean practices and performance improvement in SMEs.
- To develop a lean implementation framework for SMEs.

The key contribution of this work is comprehensive examination of the status of lean implementation in Indian SMEs and to remove the ambiguity about usefulness of lean concepts for SMEs. The findings of current research about effectiveness of lean initiations for SMEs will be useful for academicians and practitioners to bring lean initiations in SMEs. This work made an attempt to deal with the issues pertaining to embark lean initiations in SMEs. The survey and case study results will produce an overall concept of lean initiations in Indian SMEs. Present research will be helpful to analyse the reasons of limited lean initiations in SMEs. Current study also contributes to the knowledge by providing a lean implementation framework for SMEs. The ultimate goal of this research is to create opportunities for industrial managers and researchers to improve the sustainable performance of the SMEs by adoption of lean initiations. This will not only help the managers to plan strategies for the adoption of lean in SMEs but will also remove the scepticism about adoption of lean in SMEs.

1.3 Research approach

In this section, an outline of the research approach used to attain the objectives of the present study is presented. The research approach adopted for the study will include a blend of survey technique and case studies approach.

First, a clear description of lean thinking will be developed to remove the ambiguity and vagueness about the lean thinking concepts, which will further be used to explore the lean initiations in Indian SMEs. Secondly, the lean tools will be identified which have the most impact on Indian SMEs. Based on the other issues synthesized from extant literature regarding lean implementation in SMEs and identified lean tools, a survey and case studies of select Indian SMEs will be carried out to explore the status and reasons of partial lean initiations in SMEs. The research approach is explained below:

1.3.1 Literature review

Literature review will be beneficial to recognize basic concepts of lean and characteristic of SMEs. It will also offer the problems, barriers, and other issues mentioned in extant literature, which are worthwhile for the study in perspective to lean implementation in SMEs.

1.3.2 Development of survey instrument

Based on literature review a survey questionnaire will be prepared, pilot tested and refined based on the feedback of a few academicians, experts of lean and practitioners from SMEs.

1.3.3 Survey of SMEs

Structured survey questionnaire will be administered to randomly selected Indian SMEs in a view to explore the status of lean initiations in Indian SMEs. It will also explore the awareness of SMEs about lean thinking, lean tools & techniques and general perception of SMEs about lean initiations. Survey will include personal visits, e-mails, postal correspondence, third party contact and other means.

1.3.4 Scrutiny of survey data and generation of survey results

The valid responses will be scrutinized and summarized and relevant mathematical tools will be used to generate the results of survey. Statistical analysis software SPSS 20.0 and Amos 20.00 will be used for generating results of the survey.

1.3.5 Selection of SMEs for case studies and selection of issues for case studies

Case studies will be carried out in a view to explore the operational problems in select Indian SMEs and to investigate further the issues discussed in the survey. The cases will be selected based on the heterogeneity in characteristics that are important regarding lean implementation in SMEs. Case studies will be carried out to explore the issues regarding lean initiations at micro level. Case studies will be helpful to explore the current operational problems of SMEs and the possibilities of counteracting them with lean initiations. Case studies will provide the reasons for the limited or partial lean initiations in SMEs. Case studies will include explicit visits of sites, personal observations, individual interviews of managers, supervisors, and workers, use of visual aids and exploration of production and operational records maintained by the industry.

1.3.6 Analysis of case studies

The data collected from the case studies through site visits, personal interviews and personal observations etc. will be compiled and analyzed to achieve the objectives of the current research. It will provide the reasons for partial lean initiations in SMEs and the operational areas where lean thinking can be substantially beneficial.

1.3.7 Development of lean framework

Subsequently a framework for implementation of lean in SMEs will be developed. The framework will be based on lean practices and issues of SMEs. Framework will not only suggest the applicability of different lean practices but will also guide the sequence of implementation of lean practices.

1.4 Organisation of the report

This report consists of eight chapters. A summary is presented below.

Chapter 1 includes overview of the study and provides the objectives of the current study. This also presents the stages involved in the research design.

Chapter 2 is devoted for the literature review in terms of lean practices, critical success factors, barriers to implement lean and the impact of lean adoption on the performance of SMEs. It also covers the review of small and medium enterprises in terms of challenges, and characteristics. It also identifies the gaps in the literature and scope of future research and a theoretical framework for lean implementation in SMEs.

Chapter 3 focuses on the research methodology adopted to perform the current study and deals with the development of questionnaire, pilot study of questionnaire, target population and sample, data collection and data analysis tools. Several existing research approaches like experiments, surveys and case studies were studied and it was decided that a blend of survey and case study approaches is most suitable to address the research issues of lean implementation in Indian SMEs. According to the gaps identified in the literature, certain hypotheses are constructed to examine the issue of lean implementation in Indian SMEs. A survey instrument is developed and administrated to a sample of 560 SMEs taken from directory of MSME in India.

Chapter 4 is devoted primarily to the first objective of current study, which assesses the status of lean thinking in Indian SMEs. At the beginning, the organisational data of the respondent SMEs is presented and formerly the results are examined. The status of lean thinking in Indian SMEs is assessed by examining the reason of lean implementation, critical success factors for lean implementation, barriers to implement lean and level of lean practices in Indian SMEs.

Chapter 5 emphases on the second objective of current study to establish association between lean practices and performance improvements in Indian SMEs. With the help of a survey, data were collected from SMEs in India and analysed using structural equation modelling approach. The findings suggest that even in partial manner, lean is capable of improving the operational and financial performance in SMEs. Additionally, the effect of lean adoption on financial performance is found to be partially mediated by the operational measures. This is the first known study in SMEs context to investigate the operational and financial impacts of lean with use of SEM.

Chapter 6 comprises four case studies to develop deeper insights of the empirical results debated in earlier chapters. Individually case company is deliberated in details. The level of lean practices implementation and appropriate issues are also reported for each case and cross-compared with other cases. Additionally, the barriers to implement lean thinking in SMEs are also explored and modelled to assess the interrelationship among them using interpretive structural modelling (ISM) approach. The findings reveal that lack of management commitment, leadership and resources are the key barriers to lean implementation in SMEs in India. Furthermore, poor communication between different levels of the organisation and inadequate dissemination of the knowledge of lean benefits also creates hindrance in lean implementation.

Chapter 7 is devoted to the last objective of the current study, which is to develop the lean implementation framework for Indian SMEs. On the basis of extant literature survey and the results of survey analysis and cases, a theoretical framework of lean thinking for SMEs was developed. Further, a lean implementation framework is developed which comprises steps of lean implementation in SMEs. This framework not only demonstrates the way of implementing lean practices in the organisations but also helps in managing the LIBs.

Chapter 8 presents the summary of the study along with the discussions and conclusion. This chapter concludes the contribution of the present study to the body of research on the lean thinking in SMEs and provides theoretical and managerial implications. This chapter also discusses the limitation of the current study and scope and directions for future research.

Chapter 2

Literature Review

2.1 Introduction

This chapter presents a state-of-the-art review of literature of lean thinking in small and medium-sized enterprises (SMEs). It aims at the review of specific characteristics, and challenges of Indian SMEs in view of lean thinking implementation. It also emphases on the evolution of lean thinking concepts over the time and its application in different sectors. Literature review also analyse the outcomes of previous lean implementation studies in context to SMEs. It also contributes to the identification of the lean practices, which are suitable for the adoption of lean concepts in SMEs. The chapter seeks to explore the critical success factors and barriers to implement lean in SMEs. The review also presents an analysis of the probable impact of lean thinking implementation in SMEs. After critically analysing the extant literature, the conceptual framework of lean thinking for SMEs is developed and the scope of future research is identified.

2.2 The Lean Thinking Journey

After the Second World War, Japanese manufacturers recognized that they could not compete with global manufacturers with their traditional production systems. With a motive to compete with global automobile manufacturers, Toyota first launched and executed the Toyota Production System (TPS), which is considered to be the inception of lean manufacturing (Krafcik, 1988). After successful implementation in Toyota, it was adopted by European and American automobile manufacturers (Womack *et al.* 1990; Soderquist and Motwani 1999; Gulyani 2001; Arkader 2001; Cooney 2002; Motwani 2003; Seth and Gupta 2005; Lee and Jo 2007; Reichhart and Holweg 2007; Jayaram *et al.* 2008; Wee and Wu 2009; Anand and Kodali 2009; Singh *et al.* 2010; Ramesh and Kodali 2011; Bevilacqua *et al.* 2015; Onyeocha *et al.* 2015). Thereafter, it was adopted in other industrial sectors such as aerospace (Jina *et al.* 1997; Bamber and Dale 2000; Mathaisel and Comm 2000; Modarress *et al.* 2005; Parry and Turner 2006; Psychogios and Tsironis 2012; Jurado and Fuentes 2014), construction (Howell 1999; Pheng and Chuan 2001; Salem *et al.* 2005; Johansen and Walter

2007; Yu *et al.* 2009; Dentz *et al.* 2009), electrical and electronics (Forza 1996; Hines *et al.* 1999; Aitken *et al.* 2002; Doolen and Hacker 2005; Worley and Doolen 2006; Shen and Han 2006; Fraser *et al.* 2007; Wong *et al.* 2009; Wong and Wong 2011; Liu *et al.* 2013; Vinodh *et al.* 2014;), fabrication and metal processing (Prickett 1994; Boyer 1996; Demeter and Matyusz 2010), food processing (Hines and Rich 1997; Simons and Zokaei 2005; Taylor 2005; Rashid *et al.* 2010; Dora *et al.* 2015; Vlachos 2015), healthcare (Brown *et al.* 2008; Villa 2010; Grove *et al.* 2011; Atkinson and Mukaetova- Ladinska 2012; Hicks *et al.* 2016), telecommunication and IT (Robertson and Jones 1999; Taj 2005; Psychogios *et al.* 2012), service (Bowen and Youngdahl 1998; Delgado *et al.* 2010; Staats *et al.* 2011; Suarez-Barraza *et al.* 2012; Radnor and Johnston 2013) and textiles (Bruce *et al.* 2004; Comm and Mathaisel 2005; Boyle and Scherrer-Rathje 2009; Hodge *et al.* 2011). Successful application of lean across industries with diverse characteristics has supported the claim of its proponents that lean is a universal production system (Billesbach 1994; Womack and Jones 1996). However, some authors argue that this is not the case (Cooney 2002). Such authors opine that lean production provides a partial production model, and it cannot account for the range of circumstances faced by different organizations. Therefore, an ambiguity about the application of lean in industries having diverse characteristics other than high-volume, discrete manufacturing still exists.

In the last four decades, during its journey from Japan to the USA, lean has been re-defined several times with respect to different contexts. Krafcik (1988) and Womack *et al.* (1990) first reported on TPS and defined lean as a tool for waste elimination, continuous improvement, and process integration. Womack *et al.* (1990) stated that *"compared to mass production lean uses half of everything – half the human effort in factory, half the manufacturing space, half the investment in tools, half the engineering hours to develop a new product."* Before 1995, the literature mainly focused on Just-in-Time (JIT), TQM, cost reduction and process re-engineering; the application of lean was limited to the automotive sector and the scope of lean was limited to the operational level.

The period from 1995 to 2000 witnessed a shift of lean to value enhancement, value stream analysis, lean enterprise and collaboration in the supply chain. During this period Womack and Jones (1996) introduced five principles of lean: Value, Value Stream, Flow, Pull, and Perfection. Thus, waste elimination was not sufficient for defining lean and value addition was added to the definition. Lean production became lean thinking, and the applications of lean principles were extended from shop-floor level to the whole supply chain (Womack and Jones 1996). Further, during this period, lean thinking became more widespread in manufacturing organizations other than automobile manufacturers (Boyer 1996; Forza 1996; Hines *et al.* 1999).

From 2000 to 2010, the locus of lean was again shifted to a new higher level to include order fulfillment, strategy building and new product development. Hines *et al.* (2004) stated: *lean exists at two organizational levels; one is the strategic level, and another is operational level.* The strategic level emphasizes lean thinking, concentrating on the philosophical customer-centric perspective of lean. While, at the operational level, there are the lean practices that facilitate the implementation of the lean philosophy. During this period, the application of lean was extended to service sectors and project management. Shah and Ward (2003) described lean as *"a multi-dimensional tool that includes a broad variety of management practices, including JIT, quality system, work team, cellular manufacturing, supplier management, etc. in an integrated system"*.

During the early part of the current decade (from 2010 to 2016) the locus of lean shifted to strategic integration, performance measurement, financial & non-financial, social and environmental impacts. Kumar *et al.* (2013) stated: *"Lean is a dynamic process of change, integrated and driven by a systematic set of principles, practices, tools, and techniques that are focused on reducing waste, synchronizing workflows, and managing production flows."* Now, lean thinking is often associated with the lean enterprise. The perspective on lean in includes lean manufacturing, lean distribution, lean product development, and lean procurement.

It is evident from the above discussions that lean as a concept has evolved over time, and will continue to do so (Hines *et al.* 2004). However, lean has been applied to large enterprises to a greater extent for the elimination of waste, improved quality and service, reduced total cost and lead time, and ultimately to achieve higher levels of customer satisfaction. Applications of lean to SMEs, however, remain meagre and the question arises whether lean is suitable for SMEs.

2.3 Small and Medium-Sized Enterprises

There is no single definition of SMEs, and different parameters such as size, age, the number of employees, annual turnover, sales, and asset value of the organisation are used in different countries. In India, it is defined by the investment in plant and machinery. Yet, SMEs play a crucial role in developed countries as well as in developing countries. In Australia, this sector contributed around 60% of Australia's industrial value-added in 2009/10 (Australian Government, 2011). It has been estimated that 91% of the formal business entities in South Africa are SMEs and contribute 52–57% of GDP. The United States International Trade Commission (2010) reported that SMEs contributed roughly 50% of US private non-agricultural GDP. In India, this sector contributes about 8% to GDP and 40% of the total exports (Small and Medium Business Development Chamber of India, 2016).

2.3.1 **Comparison of SMEs and LEs**

Although SMEs are unable to emulate LEs regarding investments and economies of scale, they can compete on service and value metrics. SMEs can be more adaptable and flexible in satisfying customer needs, which many LEs fail to do (Antony *et al.* 2016). In this section, an attempt is made to compare SMEs and LEs by their characteristics.

The organisational structure of SMEs is typically very simple with very few levels, resulting in high visibility and accessibility of its top management to the lowest level (Carlos 2007; Laufs *et al.* 2016). This promotes quicker communication, quick decision making and swift implementation of management strategies (Kotey 2005; Hudson-Smith and Smith 2007). However, such positives are often countered by a lack of expertise and limited specialization. On the other hand, LEs have complex structures with authorities and responsibilities distributed through different levels of the organisation.

Traditionally, SMEs utilise simple operational planning and control systems, and their operations and activities are not governed by formal rules (Ates and Bititci 2011; O'Reilly *et al.* 2015). This simplicity and informality provides flexibility (Hudson-Smith and Smith 2007) and fast response to customers (Towers and Burnes 2008) but can also lead to high variability and a lack of systematic procedures. Conversely, LEs typically adopt standardised and formalised systems and procedures for planning and allocation of resources.

Table 2. 1 Comparison of SMEs and LEs

Characteristics	SMEs	LEs
Organisational Structure	Flat with few levels, fast communications, quick decision making (Carlos 2007; Hudson-Smith and Smith 2007; Laufs *et al.* 2016).	Complex hierarchical structure with many levels, distributed powers and responsibilities (Hudson-Smith and Smith 2007; Antony *et al.* 2016.
Organisational Culture and Human Resources	Job insecurity, low trust, poor communication system, lack of expertise, inadequate employees' learning and training, fewer employees- better relationships, high authority and responsibility, high encouragement of individual creativity (Ates *et al.* 2013; Darcy *et al.* 2014; Laufs *et al.* 2016; Tam and Gray 2016).	High specialisation and experience, superior communication systems and training facilities, high degree of innovation (Laufs *et al.* 2016; Tam and Gray 2016; Antony *et al.* 2016).
Standard and formalized systems	Lower degree of standardisation and formalisation, informal and simple production planning & control, flexible procedures (Towers and Burnes 2008; Ates and Bititci 2011; O'Reilly *et al.* 2015).	Standardised and formalised systems, generally rigid procedures (O'Reilly *et al.* 2015; Antony *et al.* 2016).
External links	Limited external contacts, easily accessible, able to provide quick response to partners (O'Regan and Ghobadian 2004; Darcy *et al.* 2014).	Global partners, large customer base, extensive after sale services, long-term relationships (Darcy *et al.* 2014; Antony *et al.* 2016).
Business orientation	Short-term orientation, low risk- taking ability (Ates *et al.* 2013; Antony *et al.* 2016).	Long-term orientation, high risk-taking ability (Ates *et al.* 2013).
Resources	Lack of financial resources and skilled manpower (Gnanaraj *et al.* 2012 ; Antony *et al.* 2016).	Economies of scale and high capital investment (Antony *et al.* 2016).

It has been noted that the organisational culture of an SME often reflects the personality of its top executives (Kotey 2005; Laufs *et al.* 2016). Many SMEs are results–oriented, and favourable to new change initiatives and innovations (Carlos 2007). The human resources of SMEs are characterised by wide spans of control spread across few decision makers, dominant owners, the encouragement of individual creativity (Saunders *et al.* 2013), a small degree of resistance to change and a multi-skilled workforce (Darcy *et al.* 2014). Despite managers having wide-ranging responsibilities, SMEs often struggle to attract adequate financial support (Hudson-Smith and Smith 2007; Ates *et al.* 2013) and provide limited employee learning and training opportunities (Tam and Gray 2016) which can sometimes lead to the failure of new improvement initiatives. In contrast to LEs, SMEs are more adaptable and flexible. Innovation potential is typically less in SMEs than LEs (Antony 2008). LEs typically have superior communication systems such as ERP systems. LEs have the facilities to conduct in-house training and can afford to send their employees to attend esxternal training programmes.

In SMEs, the relationship with suppliers and customers can be characterised by a small number of external interactions, close relations, good accessibility, local markets and quick response to customer feedback (O'Regan and Ghobadian 2004; Darcy *et al.* 2014). LEs have global supply chain partners with a large customer base. They have long-term relationships with partners and often offer extensive after sales service.

LEs enjoy economies of scale and are capitally intensive, which SMEs lack (Gnanaraj *et al.* 2012). SMEs are more risk averse than LEs and have a more, short-term orientation (Ates *et al.* 2013).

In summary, large firms typically have comprehensive business models, a long-term orientation, enjoy economies of scale, high risk-taking abilities, and high levels of organisational structure. Most of the existing frameworks in the literature on lean implementation have evolved based on such large-firm characteristics. Conversely to LEs, SMEs have a short-term orientation, simple organisational structures, a low risk -taking character, simple decision-making processes, resources constraints and flexible production systems. Therefore, the operational improvement frameworks for LEs may not be suitable for SMEs. For operational improvements in SMEs, an exclusive framework is required.

2.3.2 **Challenges of SMEs**

SMEs face several challenges in contemporary competitive environments. The majority of researchers identified ‘weak educational level of employees’ and ‘communication within and outside the organization’ as the prominent challenges hindering the growth of SMEs (Bhagwat and Sharma 2007; Omerzel and Antoncic 2008; Sharma 2009; Gnanaraj *et al.* 2012). The other challenges responsible for holding back the development of SMEs include ‘inefficient leadership and management skills’, ‘poor productivity and process improvement’, ‘short- sighted vision and goals’, ‘poor access to finance and other resources’ and ‘lacking in new technologies and initiatives’ (Neupert *et al.* 2006; Antony 2008; Pillania 2008; Gnanaraj *et al.* 2012; Mathur *et al.* 2012 Ates *et al.* 2013; Chaplin *et al.* 2016). A range of key papers concentrating on the challenges of the growth of SMEs is summarised in Table 2.2.

Table 2. 2 Challenges (obstacles) of SMEs

Challenges of SMEs	Supporting literature
Ineffective leadership and management skills	Jayawarna *et al.* 2007, Neupert *et al.* 2006, Gnanaraj *et al.* 2012, Thakkar *et al.* 2013
Short-sighted vision and goals	Tuteja 2001, Singh *et al.* 2005, Hudson-Smith and Smith 2007, Ates *et al.* 2013
Weak educational level of employees	Tuteja 2001, Singh *et al.* 2005, Holden *et al.* 2007, Omerzel and Antoncic 2008, Gnanaraj *et al.* 2012
Poor productivity and process improvement	Wessel and Burcher 2004, Maire *et al.* (2008), Pillania (2008), Mathur *et al.* 2012
Poor access to finance and other resources	Kock *et al.* 2007, Pitta 2008, Gnanaraj *et al.* 2012, Chaplin *et al.* 2016
Inadequate communication and IT infrastructure	Xiong *et al.* 2006, Tuteja 2001, Singh *et al.* 2005, Bhagwat and Sharma, 2007, Sharma 2009
Lack of new technologies and initiatives	Gunasekaran *et al.* 2001, Hashim and Wafa 2002, Antony 2008

2.4 Methodology

The systematic literature survey approach employed in this paper is based on Kauppi *et al.* (2013). In this review, four databases were used: Web of Science, Science Direct, Taylor & Francis and Google Scholar. In addition, twenty-two academic journals centering towards operations management as well as lean thinking are also included in the review. The keywords were identified based on prior experience and brainstorming. Keywords included lean manufacturing, lean production, lean thinking, Toyota Production System, just-in-time, JIT, SMEs, small and medium-sized enterprises, small manufacturing units and any combination of these.

The initial search from databases and academic journals yielded 8,237 and 2,835 articles respectively. The 11,072 articles were reviewed based on the title and/or abstract and, if found necessary, the full text with the pre-specified criteria. Exclusion criteria included repeated articles, low journal quality, articles not containing SMEs' context and publication type (book reviews and anonymous publications). Subsequently, 86 articles were shortlisted based on the above criteria, and after reading the full text, eventually, 42 articles were selected. Furthermore, the papers found through the cross-references were also reviewed. This resulted in 4 more relevant articles worthy to be included. Finally, 46 articles were included in the review.

2.5 Lean Thinking in SMEs

Academicians and practitioners have suggested that the application of lean principles and philosophies is not limited to large enterprises (LEs), but can also be adopted in SMEs. Owing to the basic principles of lean: the elimination of waste, value enhancement, and customer satisfaction, being generic, lean should be applicable to SMEs. It is argued that as SMEs often have higher flexibility, faster decision making and quicker response to customers, they create a positive environment for lean implementation (Chaplin *et al*. 2016).

There is limited evidence of lean implementation in SMEs in the literature and some of the cases are discussed in this section. Slomp *et al.* (2009) investigated how lean production control principles can be used in low-volume, high-variety, and make-to-order job shops. A case study of an electrical power distribution and control equipment manufacturer was presented. The results demonstrated that the implementation of lean reduces flow time and increases service level with on-time delivery performance improving from 55 to 80 percent. It was concluded that lean principles were beneficial for high variety and low-volume production SMEs. Similarly, Panizzolo *et al.* (2012) investigated the adoption of lean in developing countries and examined the lean practices implemented by SMEs. Four case studies of Indian SMEs were presented that had deployed a lean strategy to drive significant improvement in manufacturing performance.

Also, Vinodh *et al.* (2014) used an integrated lean sigma framework to reduce product defects, thereby contributing savings to the organisation. The implementation of the proposed framework demonstrated a dramatic improvement in key metrics and substantial financial savings. Vlachos (2015) developed a lean action plan for SMEs that supported the application of lean thinking in the food sector. The aim of this work was to study the adoption and implementation of lean in food supply chains. A case study of a UK-based tea company with operations overseas was demonstrated for an in-depth inquiry of lean adoption. Similarly, Dora *et al.* (2015) adopted a multiple-case-study research approach to provide an insight of lean implementation in SMEs operating in food-processing industries and concluded that the smaller the plant, a conventional set-up, and inflexible layout make it complex to implement lean.

Thomas *et al.* (2016) applied a strategic lean six sigma framework to a medium-sized UK aerospace manufacturing company and found improved on-time-delivery-in-full to customers by 26.5%, build time reduction of 20.5%, reduced non-value-added time by 44.5% and reduced value-added time by 5%. Similarly, Manfredsson (2016) employed lean principles to a textile SME and identified an overall positive effect. Alaskari *et al.* (2016) proposed a framework that can assist SMEs with the selection of an appropriate lean tool which maximise the benefits from adopting the tool.

Filho *et al.* (2016) tested the lean constructs (practices) in Brazilian SMEs that had been developed for LEs by Shah and Ward (2007). They found only three constructs out of the ten to have been adopted and implemented by the SMEs. Therefore, the frameworks for lean in LEs may not be suitable for SMEs. The above discussion indicates that although lean is mostly adopted in LEs, the literature doesn't oppose the adoption of lean in SMEs. Some researchers (Thomas *et al.* 2009; Upadhye *et al.* 2010; Alaskari *et al.* 2016; Manfredsson 2016; Thomas *et al.* 2016) successfully employed lean philosophies and principles to enhance the operational performance of SMEs (Hu *et al.* 2015). In the next section, lean practices, which have been adopted in SMEs, are explored.

2.6 Lean practices in SMEs

According to Zhou (2012), lean tools and techniques applied in SMEs are positively related to firm performance. The literature suggests that the SMEs, which have adopted lean, have employed a range of lean tools to enhance operational, financial and competitive performance. The lean practices that are important in an SME context and have been mentioned repetitively in the literature are presented in Table 2.3.

Table 2. 3 Lean practices for SMEs

Tools	Authors
Value stream mapping	Kumar *et al.* (2006), Lian and Landeghem (2007), Roth and Franchetti (2010), Jimenez *et al.* (2012), White and James (2014)
Workplace organisation and visual management	Kumar *et al.* (2006), Vinodh *et al.* (2011), Vinodh *et al.* (2014) Gupta and Jain (2015)
Pull / Kanban	Slomp *et al.* (2009), Panizzolo *et al.* (2012), Powell *et al.* (2013), Vlachos (2015)
Kaizen	Chen *et al.* (2010), Upadhye *et al.* (2010), Arya and Jain (2014), Arya and Choudhary (2015)
Changeover Reduction / Single Minute Exchange of Dies (SMED)	Mathur *et al.* (2012), Jimenez *et al.* (2012), Dora *et al.* (2015) Thomas *et al.* (2016)
Total Productive Maintenance (TPM)	Kumar *et al.* (2006), Upadhye *et al.* (2010) Jain *et al.* (2014), Vinodh *et al.* (2014),
Quality improvement (QI) tools	Kumar *et al.* (2006), Vinodh *et al.* (2011), Gnanaraj *et al.* (2012), Mathur *et al.* (2012), Mittal *et al.* (2012), and Vinodh *et al.* (2014)

2.6.1 Value Stream Mapping (VSM)

Value-stream mapping analyzes the current state and designing a future state for the series of events that take a product or service from its beginning through to the customer with reduced lean wastes as compared to current map. Kumar *et al.* (2006), Lian and Landeghem (2007), Roth and Franchetti (2010), Jimenez *et al.* (2012) and White and James (2014) found Value Stream Mapping to be the most valuable tool for separating the value added and non-value added activities, and to identify opportunities for improvements in SMEs. Kumar *et al.* (2006) utilised VSM to map the current situation of a die casting unit which helped in eliminating waste in the process. Jimenez *et al.* (2012) used a current state map to identify process wastes in winery units and proposed significant improvements in the process through the envisioning of a future state map. .

2.6.2 Workplace Organisation and Visual Management

Visual management is a way to visually communicate expectations, performance, standards or warnings in a way that requires little or no prior training to interpret. The **5S** system is a lean manufacturing tool that improves workplace efficiency and eliminates waste. Kumar *et al.* (2006) implemented shop floor 5S to standardise the workflow, to organise the work environment and to assign clear ownership of processes to employees. Parry & Turner (2006) successfully employed visual process management tools in both original equipment manufacturers (OEMs) and SMEs. Vinodh *et al.* (2011) implemented 5S in an Indian automotive valve-manufacturing unit and found reduction in wastes. Similarly, Vinodh *et al.* (2014) employed 5S on the shop floor of an Indian rotary switches manufacturing unit. It resulted in a reduction in inventories, and a cleaner environment. Therefore, it can be concluded that the implementation of workplace organisation and visual management tools can be productive for SMEs.

2.6.3 Kanban/ Pull System

Kanban/ Pull systems attempt to control the flow of work by allocating resources only when there is demand and when capacity is available. Slomp *et al.* (2009) implemented a pull system in an electrical goods manufacturing SME and observed a reduction in WIP and an improvement in operational efficiency. In a study of four Indian SMEs, Panizzolo *et al.* (2012), identified that all SMEs used pull systems with Kanbans to streamline the production.

Powell *et al.* (2013) and Vlachos (2015) applied Kanban for controlling the supply of materials in four Netherlands-based SMEs and in a UK-based food SME respectively. Hence, it appears that Kanban/ Pull systems are as applicable in SMEs as they are in LEs.

2.6.4 Kaizen

Kaizen is an approach to creating continuous improvement based on the idea that small, ongoing positive changes can reap major improvements. Chen *et al.* (2010) employed a Kaizen tool for a small manufacturing system, which resulted in a 25% reduction in unit cost, 15% reduciton in floor space requirement and a better communication network. Upadhye *et al.* (2010) implemented Kaizen with some other lean tools at an SME and reported 50% reduction in setup time, 10% increase in machine availability, and 15% reduction in cycle time. The authors also reported 25% reduction in rejections and 15% increase in capacity. Arya and Jain (2014) applied kaizen in an Indian SME and observed a reduction in process time by 44% and a saving of Rs 64,000 by recovering an 80 square feet working area. Similarly, Arya and Choudhary (2015) presented a case of the application of Kaizen in a small-machine, vice manufacturing company. The authors reported that after the adoption of Kaizen, inventory access time decreased up to 87%, total distance travelled reduced up to 43% and total time taken by the product trimmed down up to 46%. Therefore, it is evident that not only LEs but SMEs have also implemented Kaizen.

2.6.5 Changeover Reduction / SMED

SMED is a lean tool to reduce the setup time to a single digit. Hodge *et al.* (2011) argued that SMED is applicable in textile SMEs. Moreover, Mathur *et al.* (2012) utilised SMED to improve productivity in an SME and reported that average time per setup was reduced from 4.07 hrs to 3.15 hrs. With the application of SMED principles, Jimenez *et al.* (2012) also observed considerable reduction in setup time in an SME. Dora *et al.* (2015) reported that food processing SMEs improved efficiency and productivity with the help of SMED and some other lean tools. Similarly, Thomas *et al.* (2016) found that the application of a SMED approach in a medium-sized, UK-based aerospace manufacturing company resulted in a build time reduction of 20.5%, improved on-time-in-full delivery to customer by 26.5%, reduced value-added time by 5% and reduced non-value-added time by 44.5%. Therefore, it can be concluded that SMED yields similar results in SMEs as it can be in LEs.

2.6.6 **Total Productive Maintenance (TPM)**

The execution of Total Productive Maintenance (TPM) not only improves the Overall equipment effectiveness (OEE) of large industries but also enhances the OEE of SMEs by escalating the performance, availability, and quality rate of the machines (Jain *et al.* 2014). Kumar *et al.* (2006) reported that the application of TPM in a die casting unit dramatically improved OEE and resulted in considerable financial savings. Vinodh *et al.* (2014) implemented a lean six sigma framework in a rotary switches manufacturing unit (SME) and observed that machine downtime and idle time at workstations were curtailed significantly. Upadhye *et al.* (2010) implemented TPM in an Indian SME and found a remarkable rise in OEE. Therefore, it can be said that the adoption of TPM in SMEs results in operational performance enhancement.

2.6.7 **QI tools**

Generally, SMEs focus on quality and productivity improvement for customer satisfaction and several tools based on simple statistics are available which are frequently used by the SMEs (Mathur *et al.* 2012). These tools include statistical process control (SPC), cause-and-effect diagrams, process capability analysis, Pareto charts, and Poka Yoke. Gnanaraj *et al.* (2012) utilised cause-and-effect diagrams and Pareto charts to identify causes of the problems occurring in the production system. Mittal *et al.* (2012) drew a Pareto chart to assess the cause of rejections in the die casting unit of an SME. Kumar *et al.* (2006), Vinodh *et al.* (2011) and Vinodh *et al.* (2014) also employed cause-and-effect diagrams, Pareto charts, and control charts in their respective studies of SMEs. Therefore, QI tools are widely applied in SMEs.

Although, the lean practices discussed above are widely adopted in SMEs, there are other lean practices which are also employed in SMEs, but to a limited extent. For example, just-in-time philosophies (Ramaswamy *et al.* 2002, and Dowlatshahi and Taham 2009) are mostly applied in LEs while rarely adopted in SMEs. Possibly, due to the fact that JIT flow depends on production leveling within the organization and this often cannot be achieved in SMEs due to the demand variability. Similarly, it was also found from the literature survey that Cellular manufacturing and Jidoka (autonomation) are also rarely utilised in SMEs.

2.7 Critical Success Factors for Lean Implementation in SMEs

This section outlines some of the factors that are perceived to be critical for the successful diffusion of lean in SMEs. Table 2.4 presents the critical success factors for lean implementation in SMEs with supporting literature.

Table 2. 4 Critical Success Factors for Lean Implementation in SMEs

Critical Success Factors for Lean Implementation in SMEs	
Management Commitment and Leadership	Achanga *et al.* 2006; Worley and Doolen 2006; Panizzolo *et al.* 2012; Timans *et al.* 2012; Dora *et al.* 2013; Dora *et al.* 2015; Hu *et al.* 2015
Organisational culture	Panizzolo *et al.* 2012; Timans *et al.* 2012; Zhou 2012; Dora *et al.* 2013; Dora *et al.* 2015
Training and skills	Achanga *et al.* 2006; Mathur *et al.* 2012; Zhou 2012; Timans *et al.* 2012; Dora *et al.* 2013; Albliwi *et al.* 2014; Dora *et al.* 2015; Hu *et al.* 2015
Employee involvement	Panizzolo *et al.* 2012; Hu *et al.* 2015
Communication	Worley and Doolen 2006; Timans *et al.* 2012; Hu *et al.* 2015
Financial capability	Achanga *et al.* 2006; Zhou 2012; Dora *et al.* 2013; Chaplin *et al.* 2016

2.7.1 Management Commitment and Leadership

In order to secure the successful implementation of lean principles in SMEs, the commitment of top management is vital (Achanga *et al.* 2006; Worley and Doolen 2006; Timans *et al.* 2012; Dora *et al.* 2015). It is a primary responsibility of management to educate and motivate the employees to support the adoption of lean at all levels. It is imperative that top managers are committed to a long-sight vision of performance and enhancement of the employees' involvement in improvement programmes (Panizzolo *et al.* 2012). High-quality leadership ultimately promotes knowledge enrichment and effective skills amongst employees (Panizzolo *et al.* 2012). Albliwi *et al.* (2014) argued that the lack of management commitment and involvement results in the failure of lean implementation in SMEs.

2.7.2 **Organisational culture**

It is considered that the organisational culture of an SME reflects the personality of its top managers (Achanga *et al.* 2006). For successful lean implementation in SMEs, the establishment of a participative organisational culture is a crucial factor (Panizzolo *et al.* 2012; Zhou 2012; Dora *et al.* 2013). A long-term orientation, teamwork and excellent communication are vital for a transformation to lean (Dora *et al.* 2015). Hence, a supportive culture in the organisation is necessary for the adoption of lean in SMEs.

2.7.3 **Training and skills**

SMEs typically employ a workforce with relatively limited skills and often regard training as a luxury (Achanga *et al.* 2006; Mathur *et al.* 2012; Albliwi *et al.* 2014), while a lean transformation requires a high level of expertise and training. Training of SMEs' employees is essential to improve their soft and technical skills (Dora *et al.* 2015). Many other researchers such as Zhou 2012, Timans *et al.* 2012, Dora *et al.* 2013, and Hu *et al.* 2015 also reported skills and training as a critical success factor for the implementation of lean.

2.7.4 **Employee involvement**

The engagement and empowerment of employees is also crucial in the lean drive (Hu *et al.* 2015). The adoption of lean practices such as 5S and Kaizen requires the active participation and empowerment of people in the organisation (Panizzolo *et al.* 2012). Employee involvement is also necessary to remove cultural barriers and to create the positive environment for the lean transformation.

2.7.5 **Communication**

Lean transformation requires clear communication between all the partners in a value stream (Timans *et al.* 2012; Hu *et al.* 2015). Poor communication is reflected in low production rates, poor performance, and sub-standard quality (Worley and Doolen 2006). Communication is frequently cited as a key success factor in the implementation of lean in SMEs (Worley and Doolen 2006; Timans *et al.* 2012).

2.7.6 Financial capability

Financial capability is considered as a crucial factor for the successful completion of any project. Lean implementations may require investment in training programmes and consultancy. However, it was observed that SMEs often have poor financial arrangements (Achanga *et al.* 2006; Zhou 2012; Dora *et al.* 2013; Chaplin *et al.* 2016). Additionally, the financial benefits of lean adoption are achieved over a long period of five years or more which in is not always palatable to SMEs. Therefore, financial capability is also an important critical success factor for lean implementation in SMEs.

2.8 Barriers to implement lean (LIBs)

After a successful implementation of lean by large enterprises, now SMEs have also started adopting lean to improve operational, financial, social and environmental performance (Chaplin et al. 2016). Extant literature reports various tangible and intangible benefits of lean implementation (Panizzolo et al. 2012; Powell et al. 2013; Vinod et al. 2014; Dora et al. 2015; Alaskari et al. 2016; Manfredsson 2016; Thomas et al. 2016). However, in context to SMEs, literature indicates that most of the studies have presented only one or two aspects of lean implementation, for instance, lean constructs and practices (Shah and Ward 2007; Fullerton and Wempe 2009). However, only a limited part of literature has focused on other important concerns such as barriers to lean implementation in SMEs. Similar to other performance improvement initiatives, lean is also supposed to harbour enormous difficulties (Dora et al. 2016). It has been reported in the literature that dealing successfully with the LIBs while transforming to lean is mandatory for the fruitful adoption of lean (Jadhav et al. 2014).

A few researchers have studied identification of LIBs. One such study is by Jadhav et al. (2014) in which twenty-four LIBs for large enterprises have been identified. It is however argued that LIBs for the large enterprises considerably differ from the LIBs for SMEs (Bhasin 2012). As mentioned by Antony *et al.* (2016), the characteristics of SMEs are significantly different from large enterprises; therefore, it is expected that the LIBs will also be different. The organizational structure of SMEs is typically very simple with very few levels, resulting in high visibility and accessibility of its top management to the lowest level (Carlos 2007; Laufs *et al.* 2016). This promotes quick decision making and swift implementation of management strategies (Kotey 2005; Hudson-Smith and Smith 2007). However, such positives are often countered by a lack of expertise and limited specialization. On the other hand, large enterprises have a complex structure with high levels of management. The authorities and responsibilities are distributed at different levels. Hence, the LIBs for large enterprises may not be applicable to SMEs.

Table 2. 5 Barriers to implement lean (not specific to SMEs)

Barriers	References for lean
Lack of management commitment and leadership	Abolhassani *et al*. 2016; Dora *et al.* 2015; Hu *et al.* 2015; Marodin and Saurin 2015; Jadhav *et al.* 2014; Dora *et al.* 2013; Panizzolo *et al.* 2012; Timans *et al.* 2012; Singh *et al.* 2010; Scherrer-Rathje *et al.* 2009; Fryer *et al.* 2007; Achanga *et al.* 2006; Worley and Doolen 2006; Houshmand and Jamshidnezhad 2006; Sánchez and Pérez 2001
Organisational culture	Abolhassani *et al*. 2016; Dora *et al.* 2015; Jadhav *et al.* 2014; Dora *et al.* 2013; Bhasin 2012; Panizzolo *et al.* 2012; Timans *et al.* 2012; Zhou *et al.* 2012; Cudney and Elrod 2010; Liker and Hoseus 2007; Stock *et al.* 2007; Bhasin and Burcher 2006
Lack of communication	Hu *et al.* 2015; Marodin and Saurin 2015; Jadhav *et al.* 2014; Bhasin 2012; Timans *et al.* 2012; Cudney and Elrod 2010; Scherrer-Rathje *et al.* 2009; Worley and Doolen 2006
Lack of resources	Abolhassani *et al*. 2016; Chaplin *et al.* 2016; Dora *et al.* 2015; Marodin and Saurin 2015; Jadhav *et al.* 2014; Dora *et al.* 2013; Bhasin 2012; Zhou *et al.* 2012; Eswaramoorthi *et al.* 2011; Wong and Wong 2011; Pedersen and Huniche 2011; Kumar and Antony 2008; Achanga *et al.* 2006; Hudson *et al.* 2001
Resistant to change	Abolhassani *et al*. 2016; Dora *et al.* 2015; Marodin and Saurin 2015; Jadhav *et al.* 2014; Bhasin 2012; Sohal and Egglestone 1994
Lack of Employee involvement	Abolhassani *et al*. 2016; Dora *et al.* 2015; Hu *et al.* 2015; Marodin and Saurin 2015; Jadhav *et al.* 2014; Panizzolo *et al.* 2012; Wong and Wong 2011; Cudney and Elrod 2010; Upadhye *et al.* 2010; Scherrer-Rathje *et al.* 2009; Sim and Rogers 2008;

Lack of training and skills	Dora *et al.* 2015; Hu *et al.* 2015; Albliwi *et al.* 2014; Jadhav *et al.* 2014; Dora *et al.* 2013; Bhasin 2012; Mathur *et al.* 2012; Timans *et al.* 2012; Zhou *et al.* 2012; Singh *et al.* 2010; Achanga *et al.* 2006; Worley and Doolen 2006; Sánchez and Pérez 2001; Karlsson and Ahlström 1996
Cultural difference	Hu *et al.* 2015; Jadhav *et al.* 2014; Cudney and Elrod 2010; Achanga *et al.* 2006
Lack of cooperation and mutual trust between management and employees	Jadhav *et al.* 2014; Staudacher and Tantardini 2007
Lack of understanding lean benefits (measuring benefits)	Abolhassani *et al*. 2016; Marodin and Saurin 2015; Bhasin 2012; Vinodh and Balaji 2011; Shah and Ward 2007
Incompatibility of lean with the company bonus, rewards or incentives systems	Jadhav *et al.* 2014; Cudney and Elrod 2010; Upadhye *et al.* 2010; Wong *et al.*, 2009
Backsliding to old methods	Abolhassani *et al*. 2016; Marodin and Saurin 2015; Jadhav *et al.* 2014; Bhasin 2012; Wong and Wong 2011; Emiliani and Stec 2005
Lack of supplier involvement	Jadhav *et al.* 2014; Upadhye *et al.* 2010; Salaheldin 2005; Abdul-Nour *et al.* 1998

After reviewing a plathora of literature, a set of LIBs are extracted and summerised in Table 2.5. For successful implementation of lean principles, the commitment of top management is vital (Achanga *et al.* 2006; Worley and Doolen 2006; Timans *et al.* 2012; Dora *et al.* 2015). It is a primary responsibility of management to educate and motivate the employees to support the adoption of lean at all levels. It is imperative that top managers are committed to a long-sight vision of performance and enhancement of the employees' involvement in improvement programmes (Panizzolo *et al.* 2012). Additionally, the establishment of participative organisational culture is also a crucial factor for successful lean implementation (Panizzolo *et al.* 2012; Zhou 2012; Dora *et al.* 2013). A long-term orientation, teamwork and excellent communication are also vital for a transformation to lean

(Dora *et al.* 2015). Further, SMEs typically employ a workforce with relatively limited skills and often regard training as a luxury (Achanga *et al.* 2006; Mathur *et al.* 2012; Albliwi *et al.* 2014), while a lean transformation requires a high level of expertise and training. The engagement and empowerment of employees are also crucial in the lean drive (Hu *et al.* 2015). However, it was observed that SMEs often have poor financial arrangements which act as a major barrier in the adoption of lean (Achanga *et al.* 2006; Zhou 2012; Dora *et al.* 2013; Chaplin *et al.* 2016). Lean transformation also requires clear communication between all the partners in a value stream (Timans *et al.* 2012; Hu *et al.* 2015).

A majority of articles in literature on the LIBs are in the context of large enterprises; while a few have discussed LIBs for SMEs. For instance, Achanga *et al.* (2006) conducted ten case studies of UK based SMEs and identified four critical success factors (leadership and management, financial capabilities, skill and expertise, and organisational culture) for lean implementation. Bhasin (2012) performed a survey of 68 UK-based manufacturing organisations and identified barriers for large enterprises as well as SMEs. Further, Dora *et al.* (2016) explored determining factors and their impacts on lean implementation in SMEs operating in the food processing sector using a multiple case study research approach. It is observed from the literature that a few studies are discussing LIBs in SMEs and generalised LIBs for SMEs cannot be extracted from extant studies.

2.9 Impact of lean on SMEs

Figure 2.1 illustrates the various impacts associated with a lean transformation. In order to measure the performance improvement through lean thinking, generally, operational and financial measures are adopted. Operational impacts include reduction in inventory, improvement in the quality of products, waste reduction and increases in flexibility at the operational level, and reduction in cost (Shah and Ward 2003). Measurement and quantification of the operational performance are not a big task for practitioners. Furthermore, operational performance has a positive impact on the financial performance of a firm (Fullerton and Wempe 2009). Financial impacts can easily be observed as increases in profit, revenue growth, market share and total sales.

Contemporary research also focuses on social and environmental impacts of 'lean'. Lean transformation helps social performance by improving the work routines, working environment, teamwork efforts, and employee empowerment (Chaplin *et al.* 2016). The impact of lean on environmental performance can be seen through energy saving, and reduction in wastage and pollution. Ultimately the impact of a lean transformation can be arranged into one of the four categories i.e. operational, financial, social and environmental impacts.

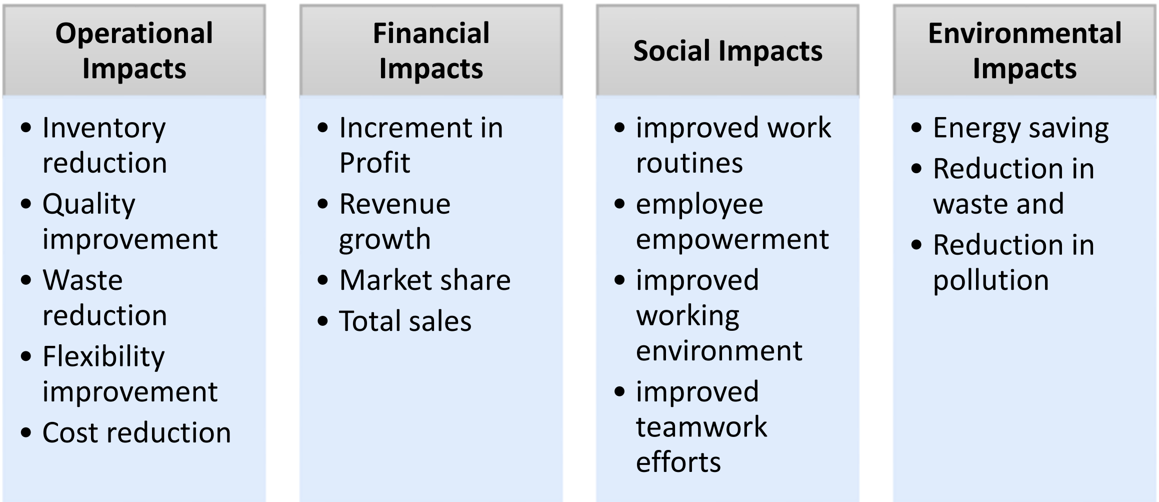

Figure 2. 1 Impacts of lean transformation

The literature was explored to judge the impact of lean in SMEs in terms of operations, financial, social and environmental performance. Shah and Ward (2003) claimed that lean practices contribute significantly to the operational performance of a plant. Fullerton and Wempe (2009) described the relationship among lean practices, non-financial measures of performance (operational) and the financial performance of the firm. For SMEs, Zhou (2012) reported improvements in operational and financial performance after transforming to lean. Chaplin *et al.* (2016) also found a positive impact of lean thinking on the social, environmental and financial performance of SMEs.

Kumar *et al.* 2006 proposed a lean sigma framework for SMEs and found that the adoption of a lean sigma framework resulted in reduced defects, improved OEE, and improved savings. Slomp *et al.* 2009 reported that lean implementation led to a reduction in 'flow times', improvement in 'service level' and 'on time deliveries' in an SME. Similarly, Vinodh *et al.* 2011 found that lean thinking positively impacted OEE while decreasing machine downtime,' 'rejection rate' and 'inventory' in an Indian automotive valves manufacturing organisation. After implementing lean sigma in a rotary switches manufacturing organisation, Vinodh *et al.* 2014 noted that the firm gained financial savings by reducing defects and improving OEE. Panizzolo *et al.* 2012 reported four case studies of the implementation of lean thinking in SMEs and found considerable impact on performance in the form of improved inventory turnover, reduced setup time, improved on-time delivery, improved OEE and higher customer satisfaction. Jimenez *et al.* 2012 also studied the impact of lean thinking in a wine-producing SME and found that the adoption of lean practices resulted in reduced production lead time and inventory, and improved the distribution of work and physical space. Chen *et al.* (2010), Thomas *et al.* (2009), Upadhye *et al*. (2010), and Thomas *et al.* (2016) also studied the impact of lean thinking on the performance of SMEs and unanimously found a positive relationship between lean adoption and performance improvement.

2.10 Conceptual framework for lean in SME

SMEs have been found to be facing a number of problems related to productivity, quality, agility, and customer satisfaction, ineffective leadership and management skills, and short-sighted vision and goals (Gunasekaran *et al.* 2001; Antony 2008; Gnanaraj *et al.* 2012; Mathur *et al.* 2012; Thakkar *et al.* 2013). SMEs also face the challenges of a weak educational level of employees, poor productivity and process improvement, fewer resources, poor communication and IT, and lacking in new technologies and initiatives. Therefore, operational initiatives for improving production processes are strongly recommended for SMEs. Recently, many researchers have utilised lean as a solution for the problems faced by SMEs. However, a comprehensive literature review suggests that in the context of SMEs, the application of lean thinking is limited to either the implementation of a small set of lean practices or only a partial implementation of lean (Bamford *et al.* 2015; Chaplin *et al.* 2016).

However, the exploration of the extant literature advocates the aplicability of lean thinking in SMEs due to their specific charecteristics. For instance, SMEs have simple organisational structures which promote quicker communication, and fast decision making which is an essential requirement for a lean transformation (Hudson-Smith and Smith 2007). Similarly, simplicity and informal rules on operational planning in SMEs provide flexibility in production and a rapid response to the customer (Ates and Bititci 2011). SMEs are also characterised by instantaneous feedback from customers and the capability for swift response to customers' needs (O'Reilly *et al.* 2015). This flexibility in production planning and the identification of customer needs creates a positive environment for lean transformation. The literature also suggests that SMEs typically have a multi-skilled workforce, a creative and innovative environment, staff with high personal levels of responsibility and few decision makers which create a positive environment for operational initiatives (Darcy *et al.* 2014). Unified, results-oriented and a corporate-mind-set culture for SMEs are also favourable for lean implementation (Carlos 2007). It is evident from the above discussion that the characteristics of SMEs can create a positive environment for lean transformation.

After reviewing the literature on lean in SMEs, it was found that practitioners mostly utilise lean practices such as VSM, workplace organisation, visual management, Pull/Kanban, changeover reduction/ SMED, TPM and QI tools, while JIT, cellular manufacturing, Andon, and Jidoka are rarely implemented in SMEs.

The literature also points to some critical success factors for the successful implementation of lean in SMEs, such as management commitment and leadership, organisational culture, training, employee involvement, and good communication. The literature in this field also suggests that the implementation of lean in SMEs has a positive impact on a firm's operational performance. Previous studies in this area reported benefits such as inventory reduction, quality improvement, waste reduction, flexibility improvement and cost reduction.

The literature review reveals that the models of lean implementation for LEs are not suitable for SMEs (Chaplin *et al.* 2016). Due to resource limitations in SMEs, only the most appropriate lean practices are productive instead of implementing full lean, and the selection of appropriate practices depends on the nature of the production process. From the literature review, a theoretical framework for lean in SMEs has been developed which is illustrated in Figure 2. 2. This framework consists of the lean practices, critical success factors (CSF), and impact factors. The CSFs are at the bottom of the framework and work as the foundation for lean adoption in SMEs. The framework proposed that for the successful implementation of lean in SMEs it is desirable to deal with the CSFs first. Above the CSFs, lean practices are present which are categorised in four groups, i.e. elimination of waste, alignment of production with demand, quality improvement and human resources practices. Implementation of lean practices impacts the performance on four broad areas: operational, financial, social and environmental which are placed at the top in the framework.

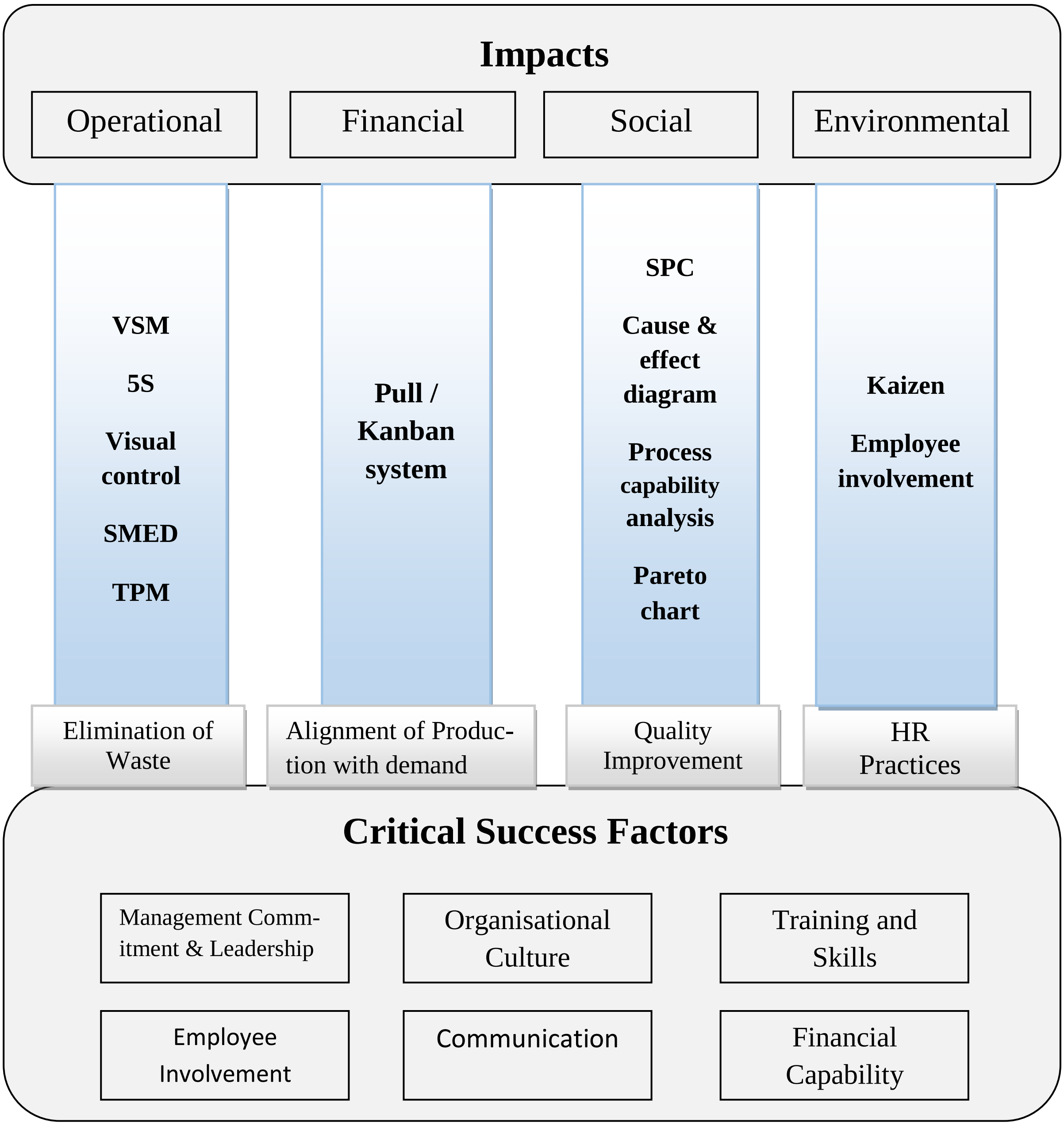

Figure 2. 2 Conceptual Framework for Lean in SMEs

A new initiative for production performance improvement in SMEs depends on the top management's commitment and involvement of employees. Therefore, before launching a lean implementation project in an SME, owner and senior executive commitment should be assured. The focus on other critical success factors is also imperative. Furthermore, to remove cultural barriers and to create the positive environment for lean implementation, HR practices such as kaizen should be employed at the initial stages of lean adoption. These practices not only provide the training to employees but also develop an understanding of lean philosophy, principles, and benefits so that the propagation of lean becomes smooth.

Subsequently, VSM should be used to analyse the current situation of the system. Since various wastes in the value stream are recognised with the help of VSM, elimination of waste and quality improvement practices should be systematically and sequentially implemented. The sequence of lean practices implementation is critical, and it depends on the key performance indicators. The sequence of adoption of lean practices creates an un-restricted value flow in the organisation.

This framework is entirely based on the comprehensive literature review carried out in this study, and can be an effective tool for implementation of lean in SMEs. However, there is always scope for adaptation of the framework according to individual SME needs.

2.10.1 Scope of future research

This review indicates that lean can be an appropriate tool for SMEs to achieve high productivity and quality with lower costs and lead times. There are, however, some issues that need attention for its effective implementation.

- **Frameworks for implementation of lean thinking in SMEs**: In the literature, numerous lean frameworks are available for LEs. For instance Jasti and Kodali (2015) reviewed 131 such lean frameworks. However, researchers have not found them suitable for SMEs (Chaplin *et al.* 2016; Hu *et al.* 2014). For SMEs, some researchers (Kumar *et al.* 2006; Vinodh *et al.* 2011; Vinodh *et al.* 2014; Thomas *et al.* 2016) have proposed frameworks for lean implementation. However, the shortcoming of these framworks is that they are derived from applications in particular industry types. Therefore, the frameworks proposed for SMEs are not generic whereas, for a widespread application of lean in SMEs a generic framework based on the charecteristics, limitations, and advantages of SMEs is required to be developed.

- **Leanness measurement models for SMEs:** An abundance of lean measurement models are present in the literature, but only a few are applicable for SMEs. To assess the degree of leanness and measurement of the state of operations is still required. Therefore, a future study is required to develop a lean measurement model for SMEs.

- **Supplier involvement:** Although supplier involvement is found to be imperative to achieve quality and delivery performance; supplier development practices are generally lacking in SMEs. Therefore, future studies are required to have attention on supplier involvement in SMEs.

- **More empirical studies:** The current literature is dominated by case studies of lean implementation in SMEs which suffers the risk of only case-specific results. In this review, only one survey-based study is found (Zho 2012). Therefore, more empirical research is needed to estimate the applicability and status of lean implementation in SMEs, and to reach generalised and valid findings.

- **Focus on developing economies:** Most of the studies in this field are conducted in developed countries (US and UK). In contrast, studies concentrating on developing economies are scarce (Bhamu and Sangwan 2014). Therefore, more research should focus on lean adoption in SMEs in developing countries.

- **Focus on financial, social and environmental impacts:** It was observed that most researchers focused on the operational impacts of lean and only a few studied the financial impacts of lean in SMEs. Therefore, an exhaustive study on financial impacts of lean in SMEs is required. Additionally, the literature also lacks studies regarding social and environmental impacts of lean in SMEs. Therefore, further studies are needed to address the social and environmental impacts of lean in SMEs.

2.11 Conclusions

This study reveals the contributions made by the existing literature pertaining to issues concerning the adoption of lean manufacturing in SMEs. To develop the understanding about the application of lean in SMEs, first the literature was explored to extract various characteristics and challenges of SMEs. This study reinforces the findings of previous research that to overcome contemporary market and competitive challenges faced by SMEs, lean can be a suitable philosophy. This study reveals that some features of SMEs encourage lean adoption while others hinder its adoption. For instance, on one hand, simple organisational structures and fast decision-making facilitates the adoption of lean manufacturing whereas lack of skilled resources restricts the lean adoption in SMEs.

In this study, the literature was also reviewed with a view to investigate the adoptability of lean thinking in SMEs. Some researchers successfully implemented lean thinking in SMEs and highlighted the benefits of lean implementaion. Therefore, it can be concluded from the critical analysis of literature that the application of lean thinking is fruitful for SMEs. Importantly, this review found that the use of all lean practices is not necessary or desirable in SMEs, but only some of the most suitable practices should be employed on the basis of the production and management characteristics (Bamford *et al.* 2015; Chaplin *et al.* 2016). Lean practices such as VSM, workplace organisation, visual management, pull / kanban, kaizen, changeover reduction / SMED, total productive maintenance (TPM), and quality improvement tools are widely implemented in SMEs while other practices have limited application.

An effort was made to identify the various critical success factors for the diffusion of lean in SMEs. These critical success factors include management commitment and leadership, suitable organisation structures, training and skills development, employee involvement, good communication, and access to finance. In order to successfully adopt lean in SMEs, these critical success factors should be considered. Furthermore, this study also focuses on the impacts of lean in SMEs and categorises them in four levels i.e. operational, financial, social, and environmental impacts.

Therefore, to transform the traditional SMEs into lean SMEs is not an easy task, however, it is worth the effort in current markets. It is assertion that to make lean implementation feasible in SMEs it is essential to understand the characteristics of SMEs and accordingly develop a holistic framework encompassing production, process, cultural, financial, managerial and environmental considerations.

Chapter 3

Research design and methodology

3.1 Introduction

This chapter aims at explaining the research methodology used in the current study. The research methodology is based on the survey of Indian SMEs to assess the level of lean implementation and the impact of lean adoption on the overall performance. The methodology illustrates the research plan, data collection techniques and the procedure that is appropriate for the research objectives mentioned in first chapter. Overall research plan is illustrated in Figure 3.1. As depicted in Figure 3.1, the research process is conducted in two phases which are design to achieve the aim. Macro phase focuses on preliminary analysis of lean practice adoption, semi structured interview, survey questionnaire and validation of conceptual lean model. Micro Phase emphases on case studies to validate the results observed from the macro phase.

The previous chapter has already described the literature review on lean initiatives in SMEs. Literature review described the basic principles and practices of lean thinking, introduction to SMEs and the critical success factors for successful implementation of lean in SMEs, based on which the research gaps were identified. Current chapter first discusses the formation of hypotheses based on research gaps. Hypotheses are formulated to achieve objectives of present study.

After constructing hypotheses, the chapter discusses existing research methods and examines their fitness to perform current research. Subsequently, survey research and case research methodologies are discussed in details along with their strengths and weaknesses. Moreover, the explanation of using a mixed method approach is presented. At the end, the chapter emphases on the course of action adopted for present research to perform and analyse the survey and case studies, respectively.

Section 3.2 discusses the hypotheses construction. Section 3.3 presents a brief overview of the research methodologies. Section 3.4 and section 3.5 highlights the characteristics, strengths and weaknesses of survey methodology and case methodology respectively. Section 3.6 justifies the use of survey for the present study complemented by multiple case studies, to achieve the objectives of present study. Stages of conducting and analyzing the survey and case studies are presented in Section 3.7 and section 3.8 respectively.

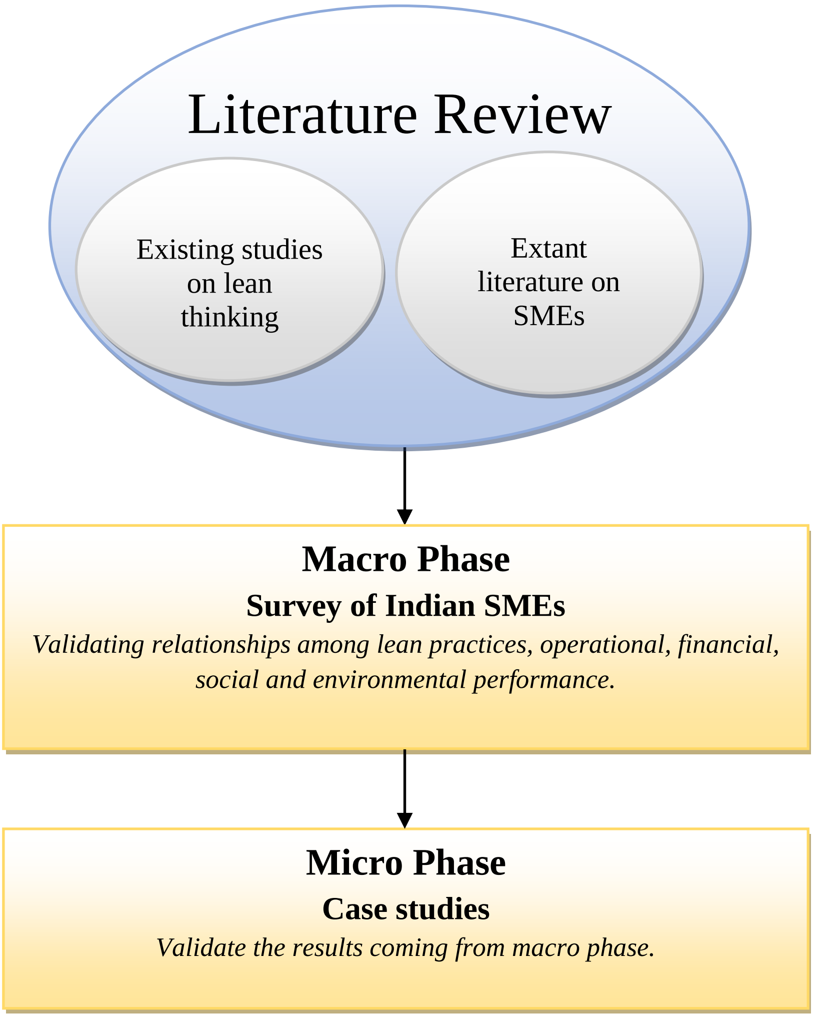

Figure 3. 1 Research methodology

3.2 Hypotheses Development

On the basis of the extant literature review and preceding logic to build up the factors of present study, certain hypotheses are formulated in conjunction to the discussion on research gaps. These issues are described below:

3.2.1 Status of lean manufacturing in Indian SMEs

There is barely any exploratory research focused upon Indian SMEs. The only exception is the survey carried out by Ghosh (2013). This was an empirical study in which 79 small, medium, and big manufacturing industries of India were considered and assessed the level of lean adoption in Indian manufacturing plants. Author concluded that numerous Indian manufacturing plants are at an advance level of lean implementation.

Moreover, considering the contribution of Indian SMEs to the economic and industrial growth, it is interesting to investigate the degree of lean adoption in Indian SMEs not only to explore the status of lean adoption in SMEs but also to remove the ambiguities related to lean issues. These issues and related hypotheses are described below:

3.2.1.1 Reasons of implementing lean in Indian SMEs

Khadse *et al.* (2013) found that most important reasons of adopting lean in Indian manufacturing firms are reduction in costs and reduction of wastes. Likewise, Garza-Reyes *et al.* (2012) explored that Indian industries believe 'customer satisfaction' as the key reason of implementing lean. Upadhye *et al.* (2010) also found that elimination of wastes from the operations is a major reason of implementing lean in Indian industries. Further, Panwar *et al.* 2015 also found similar findings that customer satisfaction, elimination of wastes, cost reduction, quality improvement and demand management are the key reasons for lean adoption. However, to investigate if Indian SMEs also perceive these reasons as the important reasons to implement lean first hypothesis is proposed in this study as below

Hypothesis H1*: *Significant reasons of implementing lean in Indian SMEs are to increase quality, to reduce wastes, to increase customer satisfaction, elimination of wastes and to decrease production costs.

3.2.1.2 Critical success factors of lean implementation in Indian SMEs

Achanga et al. (2006) identified leadership, management, finance organisational culture and skills and expertise as critical success factors for the lean adoption in SMEs. Likewise, Hu et al. (2015) also found that the key success factors for lean implementation are employee involvement, training and skills, organisational culture, and communication. However, to investigate if Indian SMEs also perceive these factors as the critical success factors to implement lean second hypothesis is proposed in this study as below

***Hypothesis H2*: *Significant critical success factors of implementing lean in Indian SMEs are management commitment and leadership, organisational culture, training and skills, employee involvement, communication and financial capability*.**

3.2.1.3 Barriers to implement lean in Indian SMEs

SMEs continue to encounter barriers which hinder them from implementing lean. For the fruitful adoption of lean in SMEs, effective management of lean implementation barriers (LIBs) is critical (Achang *et al.* 2006; Bhasin 2012; Dora *et al.* 2016). According to an estimate, merely 10% of organisations have successfully adopted lean practices (Bhasin and Burcher 2006). Ineffective management of LIBs could be a reason for such scant successful implementations (Dora *et al.* 2013). According to Achang et al. (2006), Jadhav *et al.* (2014) and Dora *et al.* (2016), the barriers directly impact on the success of lean implementation in an organisation.

For successful implementation of lean principles in SMEs, the commitment of top management is vital (Achanga *et al.* 2006; Worley and Doolen 2006; Timans *et al.* 2012; Dora *et al.* 2015). It is a primary responsibility of management to educate and motivate the employees to support the adoption of lean at all levels. It is imperative that top managers are committed to a long-sight vision of performance and enhancement of the employees' involvement in improvement programmes (Panizzolo *et al.* 2012). Additionally, the establishment of a participative organisational culture is also a crucial factor for successful lean implementation (Panizzolo *et al.* 2012; Zhou 2012; Dora *et al.* 2013). A long-term orientation, teamwork and excellent communication are also vital for a transformation to lean (Dora *et al.* 2015). Further, SMEs typically employ a workforce with relatively limited skills and often regard training as a luxury (Achanga *et al.* 2006; Mathur *et al.* 2012; Albliwi *et al.* 2014), while a lean transformation requires a high level of expertise and training. The engagement and empowerment of employees is also crucial in the lean drive (Hu *et al.* 2015). However, it was observed that SMEs often have poor financial arrangements which act as a major barrier in adoption of lean (Achanga *et al.* 2006; Zhou 2012; Dora *et al.* 2013; Chaplin *et al.* 2016). Lean transformation also requires clear communication between all the partners in a value stream (Timans *et al.* 2012; Hu *et al.* 2015). Therefore, to investigate further that which barriers are prominent while implementing lean in Indian SMEs the next hypothesis is proposed

Hypothesis H3: Significant barriers while implementing lean in Indian SMEs are lack of management commitment and leadership, organisational culture, lack of communication, lack of resources, resistant to change, lack of employee involvement, lack of training and skills, lack of understanding of lean benefits, backsliding to old methods, and lack of supplier involvement.

3.2.1.4 Lean Practices

There is no unified definition of lean because the philosophy is still evolving; however, the basic concept lies around the elimination of waste and value addition (Bhamu and Sangwan 2014). Lean is supported by various lean practices which have a positive impact on performance improvement. Shah and Ward (2007) considered ten lean practices to represent lean; one of them focuses customer involvement, three deals with supplier involvement, and rest six addresses internal process. Similarly, Hofer *et al.* (2012) used ten practice (supplier feedback, JIT delivery by supplier, supplier development, customer involvement, pull system, continuous flow, single minute exchange of dies (SMED), total productive maintenance (TPM), statistical process control (SPC) and employee involvement) to represent lean. Same practices were used by Filho *et al.* (2016) to investigate the lean adoption in Brazilian SMEs. Further, Panwar *et al.* (2018) employed TPM, 5S, quality management, work standardisation, SPC, Kaizen, visual control, long-term relationship with suppliers, small number of suppliers, supplier integration, lot size reduction, JIT purchasing, SMED, pull, and production levelling, to establish a relation between lean and operational performance.

Hypothesis H4: Significantly high used lean practices are Customer involvement, Total productive maintenance, Supplier involvement, 5S, Production levelling, Visual Management, Statistical process control, Employee involvement, Single minute exchange of dies, Pull system.

Hypothesis H5: Customer involvement enables lean thinking in SMEs

Hypothesis H6: Employee involvement enables lean thinking in SMEs.

Hypothesis H7: Supplier involvement enables lean thinking in SMEs.

Hypothesis H8: Pull system enables lean thinking in SMEs.

Hypothesis H9: 5S enables lean thinking in SMEs.

Hypothesis H10: Total Productive Maintenance enables lean thinking in SMEs.

Hypothesis H11: Statistical Process Control enables lean thinking in SMEs.

Hypothesis H12: Single minute exchange of dies (SMED) enables lean thinking in SMEs.

Hypothesis H13: Visual Management enables lean thinking in SMEs.

Hypothesis H14: Production levelling enables lean thinking in SMEs.

Based on the hypotheses H5 to H14, a conceptual model is developed for lean thinking as shown in Figure 3.2.

Majority of the studies discuss the implementation of a few lean practices in SMEs and measured its impact on operational measures (Vinodh *et al.* 2011; Vinodh *et al.* 2014; Vlachos 2015; Manfredsson 2016; Thomas *et al.* 2016). In this line, Chaplin *et al.* 2016 argued that rather than full lean, SMEs should go for lean lite (few practices). Mathur *et al.* (2012) suggested that SMEs should implement lean practices that are simple and inexpensive in use. Similarly, Bamford *et al.* (2015) conducted two case studies and found partial, as opposed to full, adoption of lean occurs in UK. Further, Chaplin *et al.* (2016) recommended "lean lite" approach (limited number of lean practices) for SMEs because of the limited financial support and knowledge. With the help of survey of Brazilian SMEs, Filho *et al.* (2016) concluded that SMEs are just implementing a few lean practices in a fragmented manner. The authors found only three lean practices out of ten represented core idea of lean in Brazilian SMEs. Thus, due to the limitation of resource, knowledge and manpower, SMEs are not able to adopt full lean thinking. Therefore, rather than adopting full lean, SMEs are implementing some of the lean practice in their organization. Therefore, to investigate the status of lean and to check the partial adoption of lean in Indian SMEs, fourth hypothesis is proposed.

Hypothesis H15: SMEs adopted a limited number of lean practices.

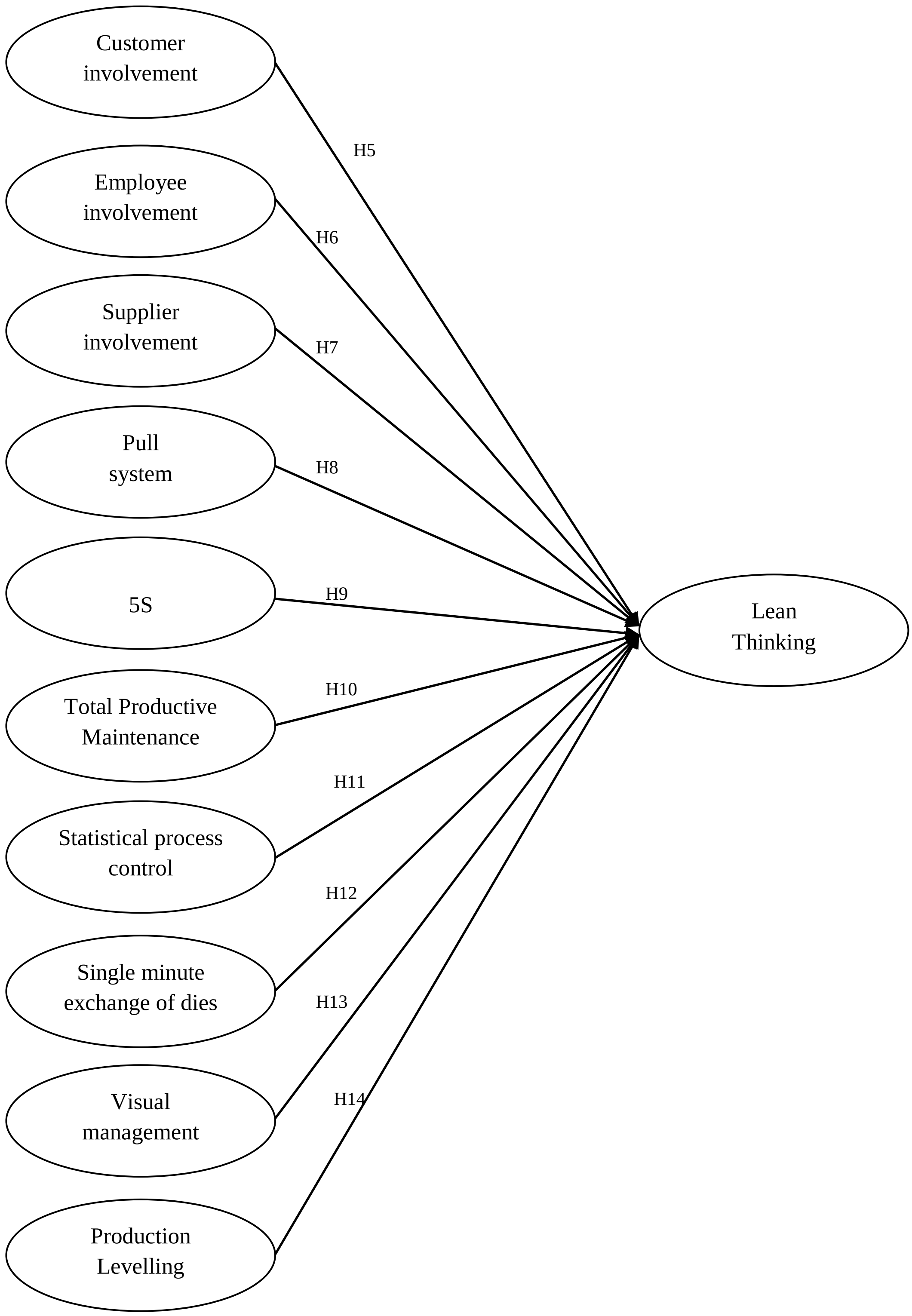

Figure 3. 2 Relationship model for lean thinking in SMEs

3.2.2 Impact of lean on performance

The prior studies have established the relation of lean adoption between the operational performance (Shah and Ward 2007; Belekoukias *et al*. 2014; Bevilacqua *et al.* 2017; Panwar *et al.* 2018). Particularly for SMEs, only a study by Filho *et al.* (2016) empirically validated this presumption. The lean implementation in SMEs is capable to augment the manufacturing performance (Panizzolo *et al.* 2012). Scholars have recorded diminished inventory level, decreased defects, enhanced productivity, reduced wastes and ultimately lower production costs as the consequence of lean implementation in SMEs (Slomp *et al.* 2009; Vinodh *et al.* 2011; Vinodh *et al.* 2014; Vlachos 2015; Dora *et al.* 2015; Manfredsson 2016; Thomas *et al.* 2016; Bevilacqua *et al.* 2017; Panwar *et al.* 2018). Similarly, Danese *et al.* (2012) tested the effect of JIT production and JIT supply on efficiency and delivery. Authors reported that although, JIT production has positive effect on both efficiency and delivery; JIT supply positively moderate the relationship between JIT production and delivery. Likewise, Panwar *et al.* (2017) demonstrated the survey findings of 121 industries which illustrate that adoption of lean practices results in a positive impact on inventory control, waste elimination, cost reduction, productivity, and quality improvement. Panwar *et al.* (2018) concluded from an empirical study that lean practices are positively associated with timely deliveries, productivity, first-pass yield, elimination of waste, reduction in inventory, reduction in costs, reduction in defects and improved demand management.

Hypothesis H16: Lean adoption positively affects the operational performance.

Improving operational performance like waste reduction, higher productivity and lower production costs directly affects the profitability of the organisation. Whereas, diminished inventory level reduces the holding cost which improves the financial benefits. On the other hand, superior quality develops the reputation, goodwill and brand value in the market and ultimately impacts on financial performance. Many empirical studies validated the presumption that lean implementation enhances the profitability of the firm. For instance, a survey study of 253 US manufacturing firms conducted by Fullerton *et al.* (2003) finds significant statistical relationships between measures of profitability and the degree of specific JIT practices used. Likewise, Fullerton and Wempe (2009) and Hofer *et al.* (2012) also detected the identical outcomes.

Hypothesis H17: Lean adoption positively affects the Financial performance.

As outline above, the operational measures like inventory, quality, production wastes and production costs affect the financial measures. Although, a plethora of literature discusses the financial implications of operational benefits; only a few have tested the mediating effect of operational measures. For instance, Fullerton and Wempe (2009) provide extensive proof that the utilisation of non-financial performance measures mediates the relation of lean adoption and financial performance. Likewise, Hofer *et al.* (2012) found that the effect of lean production on financial performance is partially mediated by inventory leanness.

Hypothesis H18: Operational performance is positively associated to Financial performance.

Hypothesis H19: The effect of lean adoption on financial performance is mediated by operational performance.

Based on the hypotheses H15 to H18, a conceptual model is developed as shown in Figure 3.3.

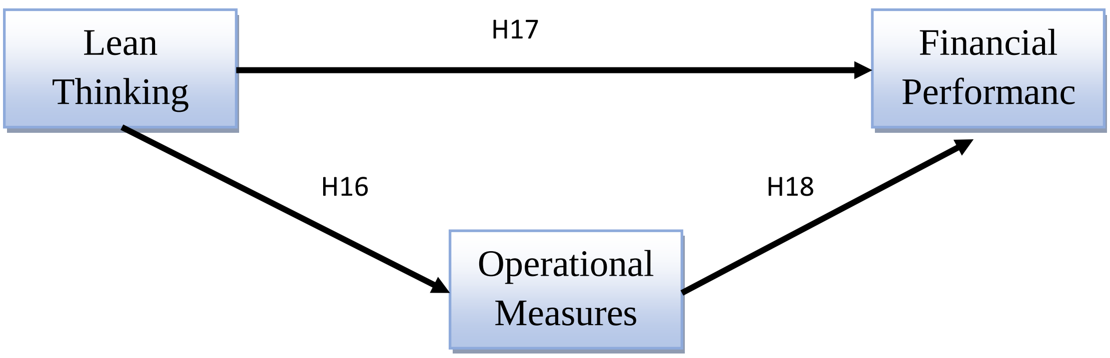

Figure 3. 3 Conceptual model for relationship of lean thinking, operational performance and financial performance.

To test above stated hypotheses and to achieve the research objectives of the present study, the selection of appropriate research methodology is presented in the next section.

3.3 Selection of research methodology

As per Yin (2003), there are five distinct research strategies: case studies, experiments, surveys, archival analysis and history (Table 3.1). Survey research is most suitable to delineate and elucidate statistically the variability of focused features of population. On the other hand, case study approach uses primarily qualitative methods with an aim to understand the underlying phenomenon completely.

Table 3. 1 Description of research methodologies

Strategy	**Form of research question**	**Control over behavioural events**	**Does focus on current events?**
Experiment	How, why	Required	Yes
Survey	Who, what, where, how many, how much	Not required	Yes
Archival analysis	Who, what, where, how many, how much	Not required	Yes/ no
History	How, why	Not required	No
Case study	How, why	Not required	Yes

Adapted from Yin (2003)

Majority of the research article regarding lean thinking adapt case studies and survey research. Researchers have found empirical studies based on surveys to be best suitable to explore the status lean implementation (Shah and Ward, 2003; Lyons *et al.,* 2011; Hofer *et al.* (2012); Ghosh *et al.*, 2013; Filho *et al.* 2016 and Panwar *et al.* 2018).

These studies present an overview of lean implementation in either a distinct geographical setting or in different types of industries, however, these studies are only exploratory in nature. Therefore, the researchers have used the case study approach to enhance understanding about implementation of lean in an exclusive industrial setup (Kumar *et al.* 2006; Upadhye *et al*., 2010; Panizzolo *et al.* 2012; and Vinodh *et al.* 2014), however, the respective authors admit that the findings produced are company specific and cannot be considered as generalizable. Therefore, it can be concluded that to explore lean implementation status for Indian SMEs a survey based study is suitable; however, to obtain deeper insights survey should be complemented by case study.

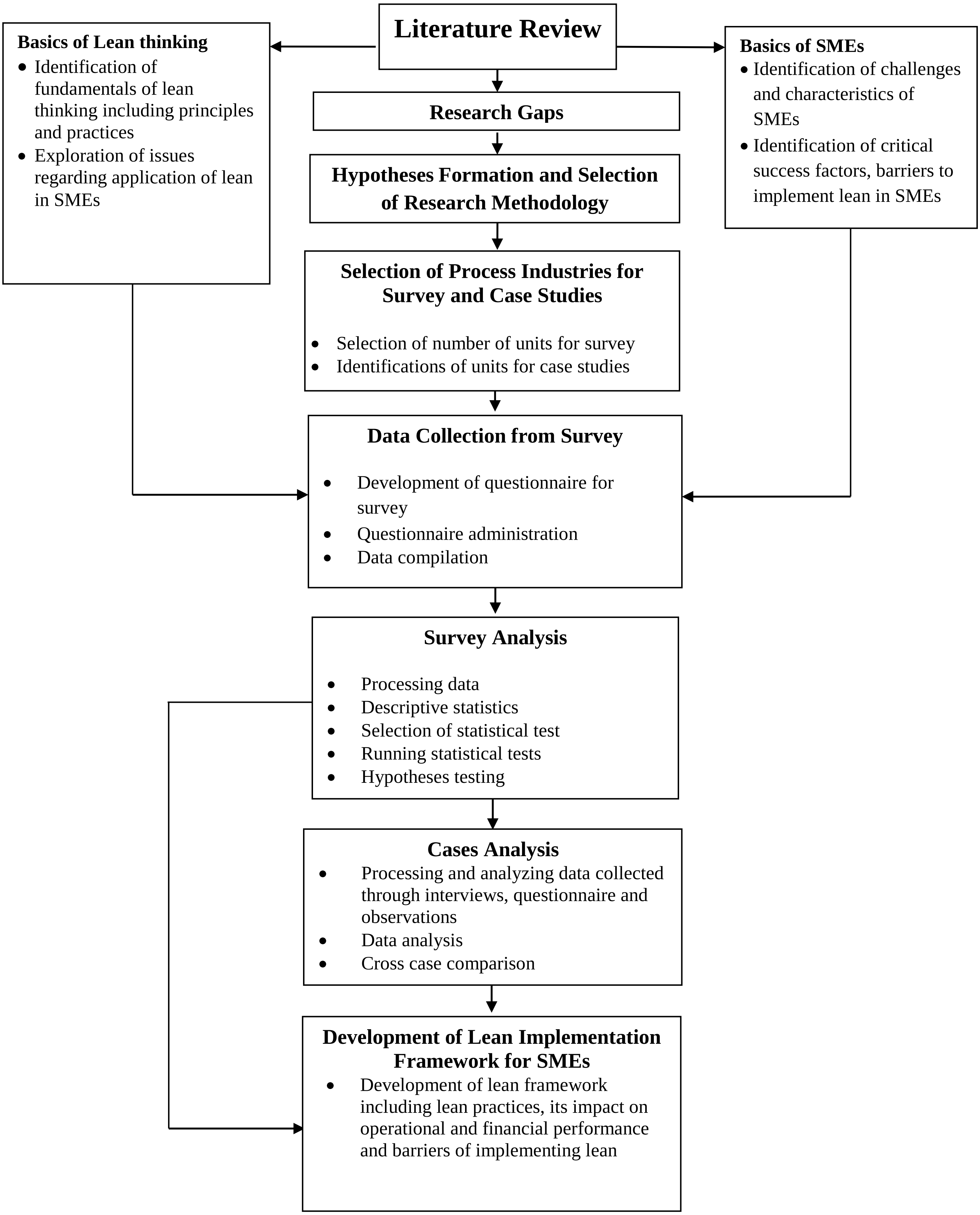

Figure 3. 4 Research plan

3.4 The Survey methodology

Survey methodology focuses on quantitative analysis. The survey comprises questions including who, what, where, how much and how many. Though, survey methods are criticized for its limitation of inability to capture the particulars needed to get in-depth understanding of the mechanics and the causes rooted in the interested processes. Survey method refers to gathering data in the form of replies to relevant questions from large number of respondents. Data may be collected through several means including, telephone interviews, mail questionnaires, or from published information (Gable, 1994). Subsequently, statistical tools are used to analyze these data. Importantly, survey approach search for identification of common relationships across firms and therefore, presents generalizable statements in accordance to the objectives of the study by analyzing a representative sample of firms.

3.4.1 Strengths and weaknesses

The strengths of survey method lie in demonstrating a 'clear and consensual view' of the issue in focus (Chauvel and Despres 2002). Because of the quantifiable nature of survey results, statistical treatment can be carried out to present results more authoritatively and with precision. Statistical inference permits the extension of results for the whole population and thus increasing the globalization of inferences. Therefore, the practitioners and researchers need not to work with the whole population and also safeguard themselves from increase in time and cost if the whole population is to be studied. Due to amenability to statistical application, survey is a more effective method to objectively verify hypotheses in comparison to other methods such as field study (Attewell and Rule, 1991). Surveys not only document the norm accurately but also identify extreme outcomes, and describe relationships between variables in a sample.

The survey methods possess relatively superior 'deductibility' over field methods (Vidich and Shapiro 1955). Jick (1983) adds that confidence in the generalizability of the results increases with survey research. Survey methodology is not only fast but it is straightforward also in comparison to other methodologies, and therefore the researchers can present results swiftly (Chauvel and Despres, 2002). Finally, inside the same context, survey research is most effective to compare results and attitudes (Stuart et al., 2002).

However, a survey predicts the causal relationships or even provides descriptive statistics accurately, only when it contains all the right questions asked in the right manner. Another limitation of survey method is its inflexibility to the developments undergone during data collection. Once the survey work is kicked off, it is impossible to make alterations, if one realizes that some crucial item was missed from the questionnaire, or that a question is vague or is being understood incorrectly by the respondents. So, it is a prominent pre-requisite of a survey that the scholar has a strong idea of the answer prior to starting a survey. Therefore, conventional survey research often believed to be appropriate for verification in spite of discovery.

Survey approach usually offers only a "snapshot" of the condition at a certain point in time and not provides any sizeable information on the underlying connotation of the data. Subsequently, the survey research does not offer appropriate measurement for some variable which the researcher seeks to study.

3.5 Case study

Case study approach, by utilizing a group of methods, stresses on qualitative analysis (Yin, 2003). Meredith (1998) provides a comprehensive and self explanatory definition of ‘case study research’ encompassing all operational features of this approach:

“A case study typically uses multiple methods and tools for data collection from a number of entities by a direct observer (s) in a single, natural setting that considers temporal and contextual aspects of the contemporary phenomenon under study, but without experimental controls or manipulations.”

Case study approach uses both quantitative and qualitative methods with an aim to understand the underlying phenomenon completely. According to Gubrium (1988) case study research is a scientific approach to correlate the theoretical concepts with real time events. Key contribution of case study research is the ability to highlight what is really happening on the ground (Thomas, 1966).

3.5.1 Strengths and weaknesses

Based on the works of Benbasant et al. (1987), Meredith (1998) pointed out three major strengths of case research methodology:

- In case study research the phenomenon under examination can be observed in natural setting, thus building a meaningful and relevant theory based on the observations of real practices.
- Case research provides high degree of understanding of the nature and complexity of phenomenon because it emphasizes on comparatively more useful question of 'why' rather than 'how' and 'what'.
- Case study methods help to early exploratory investigations even when the variables are not completely known and the phenomenon is still to be understood.

Yin (2003) identifies that case study can be used to explain a hypothesis and the results of a case study are often rich in its explanation of phenomenon. In the situation of paucity of theory and complexity of phenomenon with lack of well-supported definitions and metrics, case study approach offer more promising results than other approaches.

However, researchers discuss a few limitations of the case study research. Meredith (1998) explains that the need of direct observations in the actual contemporary condition leads to the difficulties of cost, time and access hurdles. Case study research is also subjected to requirement of multiple methods, tools and entities in a view to triangulate data, lack of control and the contextual and temporal dynamics complicacies. Another problem with case research is the limited knowledge of procedures of case methods, thus increasing the construct error and limiting the validation and generalizability. Lee (1989) also observed that lack of controllability, deductibility, repeatability and generalizability are four major problems associated with case study research.

3.6 Integrating case study and survey research methods

It is clear that use of survey research or case research in isolation lend to certain limitations. Thus, complementarities between survey and case research have increased the interest of researchers to use a combined research methodology (Gable, 1994). Kraemer, (1991) identified that although survey research is an effective methodology but the results are immensely improved if another research methodology such as case study is used in conjunction.

Survey proves to be useful to explore 'how' and 'what' aspects of phenomenon, whereas case study facilitate to deeper understanding of the phenomenon by providing answer to 'why' aspect with more penetrating questions. Attwell and Rule (1991), state that both survey research and case study are not complete without supporting each other. Using a mixed approach is more desirable in situations where a newly emerging subfield is to be studied.

Wynekoop (1992) suggests that quantitative 'macro-level' analyses should be followed by a qualitative 'micro-level' analysis to elucidate a phenomenon thoroughly. Table 3.2 illustrates the relative strengths of survey method and case method (adopted from Gable, 1994).

Table 3. 2 Relative advantages of survey and case research approach

Factors	**Survey**	**Case study**
Controllability	Low	Medium
Deductibility	Low	Medium
Repeatability	Low	Medium
Generalizability	Low	High
Discoverability (explorability)	High	Medium
Representability (potential model complexity)	High	Medium

(Adopted from Gable, 1994)

Above discussion and Table 3.2 confirms that most of the weaknesses of on method are compensated by another method. Therefore, considering the advantages of combining survey with case studies, a combined research methodology was deemed to be most appropriate for the present research. Hence, a survey based on a structured questionnaire followed by multiple case studies was decided as the research methodology to carry out present research. Literature provides several evidences of adoption of such a mixed research methodology in the area of lean implementation in industries for quite some time (Arlborn *et al.,* 2011; Motwani, 2003; Durrani *et al.*, 2014 and Spencer and Guide, 1995).

3.7 Procedural steps of survey research

The survey comprised of following steps:

3.7.1 Development of survey instrument

Comprehensive literature review lead to the establishment of three objectives of present study. Prior researches related to lean implementation in global context and in Indian context have used structured questionnaires to explore issues related to lean adoption (Shah and Ward, 2003; Hofer *et al.* (2012); Ghosh 2013; Filho *et al.* 2016 and Panwar *et al.* 2018). Hence, a structured questionnaire was chosen to collect data as it provides strong base for results generalization. Moreover, accordingly to Blumberg *et al.* (2011), statistical methods can be easily applied on the data collected through structured questionnaire. The survey questionnaire was build upon the perception of respondents concerning the degree of lean implementation and operational, and economic performances in the respective SMEs. This is in parallel to most empirical quantitative studies within lean implementation and performance related studies, for instance Shah and Ward (2003), Shah and Ward (2007), Lyons *et al.* (2011), Bhasin (2012), Garza-Reyes *et al*., (2012), Hofer *et al.* (2012), Ghosh (2013), Filho *et al.* (2016) and Panwar *et al.* (2018). Furthermore, information based on the perceptions of respondents usually considered being nearest to reality, in comparison to the data collected independently by the researcher through an artificial reconstruction of the objective reality (Ahire *et al*., 1996).

First objective of the present study was to explore the status of lean manufacturing in Indian SMEs. Four issues are grounded in the extensive literature review conducted in previous chapter to explore status of lean. These issues include 'reasons of lean implementation', 'extent of use of lean practices', 'critical success factors for lean implementation ', and 'barriers to implement lean thinking'. Second objective of present research was to estimate performance improvement through adoption of lean in Indian SMEs. To assess performance improvement, perception about level of performance based on frequently mentioned performance factors in literature, was required. The questionnaire was developed to accommodate all the issues mentioned here.

The questionnaire was split in three parts. First part contained six questions about general information of the company. The first part of the questionnaire contained questions such as 'type of company', 'investment in plant and machinery', 'type of organisation', 'type of customers', 'type of production process', and 'number of employees'. The second part of questionnaire had five questions related to awareness about lean manufacturing. Second part had questions such as 'familiarity with lean', 'perception about usefulness of lean', 'barriers to implement lean', 'critical success factors for lean implementation', and 'adoption of lean manufacturing'.

Last part of the questionnaire was related to lean manufacturing issues. There were questions to identify 'adoption of level of lean practices', and 'level of performance in the organisation'. Table 3.3 summarizes the lean implementation issues and their corresponding items identified along-with the literature sources.

As suggested by Malhotra (2006), Likert scales are most appropriate as the respondents can understand it with no difficulty. Also, the respondents can easily vary their answers if Likert scales are used. Thus, Likert scales were used to measure the reply of respondents. Seven point Likert scale which ranged from 1= no implementation and 7= complete implementation was used for the measures of 'lean practices'. To measure 'reasons of implementing lean', 'barriers to implement lean', 'critical success factors to implement lean' and 'performance measures' were measured on seven point Likert scale with 1= not important and 7= most important.

During the development of the questionnaire, a key consideration was to formulate the questions in an easy and understandable language without compromising with the conceptual content underlying the questions. A pilot survey was carried out before administering the questionnaire, in order to obtain feedback and to guarantee that respondents easily understand and relate to the questions mentioned in the questionnaire. Two SME owners, two production manager and two professors, having vast experience in teaching operations management and lean manufacturing, each studied the questionnaire and subsequently, the questionnaire was discussed with them thoroughly. This discussion was proved to be helpful to maintain the quality of questionnaire in the form of appropriateness and focus on relevant issues. This discussion led to minor amendments in the questionnaire, mostly characterized by rewording of terminologies and eliminating a few items. Further a field pilot testing was carried out with twenty-eight SMEs from randomly selected respondents of the population. All the replies were collected through personal visits and three questions were revised as per their opinion. Finally, a structured questionnaire was designed. A copy of the survey questionnaire is furnished in Appendix I.

Table 3. 3 Issues mentioned in the questionnaire

Lean Implementation issue	No. of items	Items	Literature source
Barriers to implement lean	10	Lack of management commitment and leadership Organisational culture Lack of communication within the organisation Lack of resources Resistance to change Lack of Employee involvement Lack of training and skills Lack of understanding lean benefits (measuring benefits) Backsliding to old methods Lack of supplier involvement	Achanga et al. (2006), Dora et al. (2016), Jadhav et al. (2014), Bhasin (2012)
Reasons of implementing lean	**6**	To eliminate of wastes To decrease production costs To improve quality To improve productivity To increase demand management efficiency To increase customer satisfaction	White (1993), Taj (2008), Singh *et al.* (2010)
Critical success factors to implement lean	6	Management Commitment and Leadership Organisational culture Training and skills Employee involvement Communication Financial capability	Achanga et al. (2006), Zhou (2016), Hu et al. (2015), Dora et al. 2015
Lean practices	43	We are in close contact with our customer Customers give feedback on quality and delivery performance Customers are actively involved in current and future product offerings Customers frequently share the demand information Shop floor employees are actively involved in problem solving Shop floor employees are actively involved in process improvements Shop floor employees regularly give suggestions for product improvement Shop floor employees undergo cross functional training We give our suppliers feedback on quality and delivery performance We strive to establish long term relationship with our suppliers Our key suppliers are located in close proximity to our plant We take active steps to reduce the number of suppliers in each category Production is pulled by shipment of finished goods. Production at workstations is pulled by the demand of the next station	Shah and ward (2003), Hofer et al. (2012), Ghosh (2013), Filho et al. (2016), Panwar et al. (2018),

		We use Kanban, squares or containers of signals for production control We use pull system to control the production rather than schedule prepared in advance Only the materials which are actually needed are present in the work area. Only tools and hand tools which are needed are present in the work area. Locations for all production materials are clearly marked out and the materials are stored in the correct locations. Areas for WIP (Work In Process parts) are clearly marked. Work areas, storage areas, aisles machines, tools, equipment and offices are clean/neat and free of safety hazards. Regularly schedule housekeeping tours and periodic self assessments (5S audits) are conducted. We maintain all our equipment regularly. We maintain records of all equipment maintenance activities. We ensure that machines are in high state of readiness for production at all the time. Operators are trained to maintain their own machines. Charts showing defects are used as tools on the shop floor We use diagrams like cause & effects (fishbone) to identify causes of quality problems We conduct process capability studies before product launch Extensive use of statistical techniques to reduce process variance We are working to lower setup time in our plant We have low setup times of equipment in our plant Operators perform their own machines setups. Operators are trained on machine setup activities. We emphasize to put all tools in feasible area to the operator. Equipment are identified with signages Process parameters are displayed on shop-floor Manufacturing performance is displayed on shop floor We produce more than one product model from day to day (mixed model production) We emphasize on a more accurate forecast to reduce variability in production. Each product is produced in a relatively fixed quantity per production period. We emphasize to equate workloads in each production process. We produce by repeating the same combination of products from day to day. We always have some quantity of every product model to response to variation in customer demand.	
Performance measures	17	We have low Inventory level The Quality of products is satisfactory. Our Productivity is high. We have low Production wastes. Our Production Costs are less. Organisation enjoys high Profit Firm has high Revenue Market share of the firm is significant. Total sales of the organisation are high. Work routine of the employees good Employee empowerment Employees are satisfied with Working environment Employees are working as in Teams Employees do not leave the company frequently Energy/power saving is significant Industrial Wastes are very less Pollution is under control	Shah and ward (2003), Fullerton et al. (2003), Fullerton and Wempe (2009), Hofer et al. (2012), Panwar et al. (2018)

3.7.2 Administration of survey

A sample of 560 SMEs was taken from directory of MSME certified industries in India. Responses were collected through conducting face to face interviews. In some instances, responses were collected through third party channels. The questionnaire was addressed to higher executives who were responsible for production. Finally, 382 responses received and the response rate was approximately 68% that was good enough for further analysis.

3.7.3 Reliability of instrument for internal consistency

It is essential to measure the reliability of the instrument when the variables developed from summated scale are used as predictor components in objective models (Santos, 1999). In other words, a measuring instrument should provide consistent results, and for it, test of reliability is carried out. Reliability analysis of a questionnaire establishes its ability to yield consistent results. In present study reliability was assessed through internal consistency, which is the degree of inter correlation among the items which build a scale (Flynn *et al.*, 1994). Cronbach's alpha (reliability coefficient) was used to measure internal consistency (Cortina, 1993). Variables having value of alpha more than 0.60 were considered to be highly reliable.

3.7.4 Survey analysis

Data Analysis can be defined as 'a systematic and orderly approach taken towards the collection of the data so that information can be obtained from the data'. It is difficult to draw conclusions from empirical data and to generalize them without the assistance of statistical evidence. The IBM Statistical Package for Social Sciences (SPSS) version 22.0 and IBM SPSS AMOS 22.0 software package was used to analyze the data. Eswaramoorthi *et al.* (2011) conducted a survey to investigate the status of lean practices in the machine tool manufacturing and used SPSS to analyse the data. Nordin *et al.* (2010) used SPSS to analyse the data collected to elucidate the lean manufacturing implementation in Malaysian automobile industry. So and Sun (2010) investigated the influence of important factors of supply integration strategy on lean manufacturing adoption in a global survey of 558 firms situated in 17 countries. Authors analyzed the relationships in SPSS. Similarly, several other studies in context to lean implementation have used SPSS for statistical analysis (Singh *et al.,* 2010b; Narasimhan *et al.,* 2010; Oliver *et al.*, 1996; and Rothenberg and Cost, 2004). The various statistical procedures were followed to get the proper inference of collected data and to test the research hypotheses. The following tests were briefed.

3.7.4.1 Preliminary analysis

A preliminary examination of data was carried out. These were used to conduct a preliminary analysis and to ensure validity of responses. Cronbach's alpha coefficient, composite reliability, Mean, Standard deviation, Skewness & Kurtosis and confirmatory factor analysis was performed as an appropriate statistical test for assessing the reliability and validity of instrument using SPSS 22.0 and AMOS 22.0 software package.

3.7.4.2 Test of Independence

The Chi Square one-variable test was used to test the association between two variables. The test of independence hypothesizes that the two variables are unrelated--that is, that the column proportions are the same across columns and any observed discrepancies are due to chance variation.

A larger chi-square statistic indicates a greater discrepancy between the observed and expected cell counts; that the hypothesis of independence is incorrect, and, therefore, that the two variables are not independent.

3.7.4.3 Analysis of Variances (ANOVA)

Analysis of variance (ANOVA) is a procedure, which is used to make comparisons among three or more means. One-way ANOVA is used to calculate F-statistic for testing relationship between several variables in this research.

3.7.4.4 Factor Analysis

In this research factor analysis is used by using SPSS 22.0 to extract the factor structure for the research. Similarly, reliability and validity of constructs are also evaluated.

3.7.4.5 Confirmatory factor analysis (CFA)

In order to test the psychometric properties of the scale items, a confirmatory factor analysis was performed by using SPSS Amos 22.0. In this various measures such as convergent validity and discriminate validity of the items were evaluated. In this study AMOS 22.0 was used to model the first order factors and how these factors measure the second order dimension (Sustainable manufacturing) was ascertained.

3.7.4.6 Structural equation modeling (SEM)

Structural equation modeling is increasingly gaining acceptance in many research disciplines. SEM is being employed as a powerful alternative to multiple regression, path analysis, factor analysis and analysis of variance (Hair et al., 2006). SEM model is used to test the theoretical model, and to help establish the association between constructs. It provides the powerful data analysis technique that allows the entire theory put forward in a research model and tests it simultaneously by examining the structure of interrelationships expressed in a series of equations, similar to a multiple regression equation (Hair et al., 2006).

Structural model using Amos 22.0 has been created to test the proposed hypothesis. In order to evaluate the model fit; various model fit indices, such as chi- squire value, CFI, AGFI, NFI RMSEA, GFI were evaluated. The path loadings and their significance were evaluated to check; how well the measurement scale predicts the dependent variables.

3.8 Procedural steps of case studies

Case studies for current research included the steps described below:

3.8.1 Selection of cases

While designing a case study research, most important issue is selection of number of cases. Although, a single case better explains a well defined established theory, however, to investigate the application of a new theory in a new setup, multiple case studies are preferred. Results of a single case cannot be generalized because the results remain to be case specific (Voss *et al.*, 2002). If the purpose of the research is to describe a phenomenon, or to develop and test theories, multiple case study approach is advantageous. Multiple cases studies also facilitate cross case comparison which is deemed to be highly important for the generalization of theories. Selection of cases for multiple case studies should be made such that either the cases produce similar results or synthesize counterintuitive results for a predictable cause (Voss *et al.*, 2002). Multiple case studies are also highly useful to establish the results of exploratory analysis and to achieve deeper insights of the results achieved from survey analysis. For the present study also, it was decided to use multiple case studies, because:

- SME is not one industry but a collection of various industries producing a wide variety of products. The broad spectrum of SMEs cannot be represented by a single case.
- Multiple cases will increase the external validity and generalizability of results.
- A comprehensive survey of lean implementation issues will be carried out prior to case studies. Therefore, to get deeper insights of the issues discussed in survey and for the confirmation of the results, multiple cases will be helpful.

Present study involved results of four cases. There is no thumb rule to decide number of cases. Therefore, keeping a balance between constraints of resources such as time and cost and the details achieved from each case, four cases were selected for study. The case studies were carried out with the aim that the four cases together will combine to lead to a better understanding of lean adoption in Indian SMEs and will help in interpretation of propositions formulated in present study. The case studies would also help to check the viability of proposed lean implementation framework.

The cases were selected in such a way as to maximize variation on dimensions that are of potential importance for the degree of lean implementation according to the extant literature. The cases were chosen that were expected to be different with regard to heterogeneity on production dimensions such as; raw materials and products; production process; degree of inventory levels; stage of product discretization and other characteristics which are important regarding lean implementation. To keep anonymity the names of the case firms are not disclosed. The focus of present research is 'implementation of concepts of lean in Indian SMEs', hence, all the investigation were carried out in the SMEs located in India only. The case industries are:

Case A: Automotive Supplier (B2B type)

Case B: Bearing Manufacturer (B2B type)

Case C: Water purifier manufacturer (B2C type)

Case D: Medical equipment manufacturer (Mix type)

3.8.2 **Data collection**

Pannizzolo (1998) emphasize that to study a complex system such as lean, multiple data collection methods are required. Therefore, to collect maximum information, which was sought to be essential for comprehensive discussion of issues, all possible means were utilized. The case companies were studied through the visits of the plants together with interviews of personals, exploration of official documents and a questionnaire. Wherever possible, documents pertaining to implementation of improvement initiatives, operating procedures, sales data and plant layout were obtained from the observed sites. Table 3.4 lists the data collection methods used at a particular case.

Table 3. 4 Data collection methods used in case sites

Data collection method	Case 1	Case 2	Case 3	Case 4
Interview	√	√	√	√
Plant visit	√	√	√	√
Questionnaire	√	√	√	√
Documents	√	√	√	X
Note: √ = Yes	X = No			

The initial contact with each SME was made by telephone. This initial contact primarily served the purpose of determining a willingness to participate and to schedule an onsite visit. It took minimum 3 calls and as many as 10 calls to get consent for the plant visit. However, all plants needed a written document about the purpose and scope of study to ensure that the research outcomes will be used only for study purposes. All the cases demanded a request letter and a copy of questionnaire in advance before sanctioning the plant visit. Understanding the policy and security reasons anonymity was promised to each case in prior, in the cover letter. To save the time of everyone, preliminary information about the sites were extracted from resources such as internet, annual reports and library. Subsequently, on-site meetings were arranged with concerning personals in different firms.

Tours of each plant were extensively planned and interviews were combined with physical visits. At the outset of an interview, the first job was to briefly explain the motive of the research and simultaneously describing the lean manufacturing paradigm with associated lean practices. The interview was mainly focused on information regarding lean manufacturing implementation such as adoption of lean practices, challenges faced during implementation of operational improvement initiatives, reasons of adoption of improvement initiatives and performance assessment based on performance factors mentioned in questionnaire.

Interviewees included owners and production managers. The initial interviews were followed by a plant visit covering all the sections of plants as much as possible. The visits were coupled with informal discussions. During the visit of functional departments questions were asked when required which were answered spontaneously. At the end of plant visit, a brief meeting was arranged with the concerning personal to clarify any doubts or any other outstanding questions. Wherever possible or allowed, supporting documents such as plant layouts, sales figures and lean implementation documents were gathered. Interview sessions were lasted between 2 to 6 hours, and, 2 to 8 hours were spent in plant visits. Subsequently, the information collected through interviews, observations during plant visits and documents was compiled in proper format for the purpose of analyses.

3.8.3 **Case analysis**

The procedure of case analysis for this study started with processing and analyzing interview data, and data collected during plant visit. Each case was analysed comprehensively about its status of lean implementation and relevant issues. Finally, a cross case comparison was conducted among the observed SMEs. Cross case comparison was carried out to assure the generalizability of findings.

Finally, case studies were used to explain the results of the survey. Survey findings were more exploratory in nature and provided initial information supported with certain hypotheses, however, case studies were used to get more penetration in the issues. The counterintuitive findings of survey were also explained with the help of case studies. The results of survey and case study were also compared with the earlier global studies as well as the studies carried out in context to India.

3.9 Conclusion

Firstly, the research plan is discussed, thereafter chapter outlines the hypotheses construction related to the objectives of present study. Further, the chapter highlighted the strengths and weaknesses of different research approaches. It was found that survey methodology is most suitable to delineate and elucidate statistically the variability of focused features of population, whereas, to explain the phenomenon with deeper understanding a case study approach is required. Hence, considering the nature of present research and to take advantages of both methodologies, a mixed research approach was adopted for present research. The combined research methodology has been followed in the area of lean manufacturing adoption for quite some time (Arlborn *et al.,* 2011; Motwani, 2003 and Durrani *et al.*, 2014). Several advantages are associated with this research methodology such as cost efficiency, wider reach, greater anonymity and more in-depth exploration of issues.

Subsequently, the chapter outlined the development of the survey instrument and explained how each part of the questionnaire (and questions within each part) has been developed from theory and previous research. After development, the questionnaire was discussed with the practitioners and academicians having experience related to lean and operations management. Then the chapter delineated full administration of the final questionnaire. 560 SMEs of India were randomly selected from the MSME directory as the target respondents. It also discussed the selection strategy for cases. Four cases were selected for case study. It outlined the procedure adopted for conducting the case studies and collecting data. The next chapter summarizes the key findings of the survey conducted in this research.

Chapter 4

Survey findings and analysis

4.1 Introduction

Many scholars have reported that the adoption of lean thinking is continuously growing in Indian industries (Ghosh, 2013; Panwar *et al.*, 2017), but this application is limited to large enterprises (Bhamu *et al.*, 2014). On the other hand, there is a lack of research regarding adoption of lean thinking in Indian SMEs. Globally, the application of lean thinking in SMEs has been very little studied so far. Present research fills this gap through empirically testing the adoption of lean and its impact on performance in Indian SMEs. This chapter discusses the survey findings and some hypothesis testing.

One of the objective of the research was *to explore lean implementation issues in Indian SMEs.* Earlier to conversing the issues of lean adoption in SMEs, respondent's familiarity with the concept 'lean thinking' is discovered. Likewise, the perception about lean thinking regarding its usefulness and, then investigation of adoption of lean is explored.

Consequently, the level of lean adoption in Indian SMEs is analysed by assessing the degree of implementation of lean practices. Extent of use of all lean practice is summed up for every respondent and then the degree of lean implementation in Indian SMEs is analyzed. It is followed by the assessment of the important issues regarding lean implementation in Indian SMEs by testing concerning hypotheses. At the outset, the significant reasons of implementing lean in SMEs are found out through statistical analysis. It is followed by the identification of statistically significant critical success factors for lean adoption in SMEs. Subsequently, significant barriers of lean implementation in SMEs are explored. Lastly, analysis is carried out to recognise the lean practices, which are widespread in Indian SMEs, and the lean practices, which are rarely used.

Section 4.2 and section 4.3 illustrate the number of responses achieved and respondent's characteristics, respectively. A measurement of level of lean implementation in Indian SMEs is carried out in section 4.4. Subsequently, section 4.5 presents the statistical results of the assessment of the important issues regarding lean implementation in Indian SMEs. The issues include reasons of implementing lean, critical success factors of lean implementation, and barriers to implement lean in SMEs. Finally, section 4.6 provides the conclusion of the chapter.

4.2 Survey observations

The survey was carried out in SMEs covering fifteen states: Andhra Pradesh, Bihar, Delhi, Goa, Gujarat, Haryana, Jharkhand, Madhya Pradesh, Maharashtra, Punjab, Rajasthan, Tamil Nadu, Uttar Pradesh, Uttrakhand and West Bengal in India. The survey was conducted from June 2017 to October 2017. The survey companies were randomly identified from the database of the Confederation of Indian Industries (CII) and Ministry of micro, small and medium enterprises (MSME). Although 560 SMEs were contacted, total 382 usable responses were collected. All the responses were collected through personnel visits (face-to-face interviews) and the response rate was approximately 68% that was good enough for further analysis. Responses rate through mails was less than 1 percent. Therefore, we visited to four industrial fairs (MSME) at Gurugram, Pune, Kolkata and Gandhinagar and collected data from 286 SMEs. Rest of the responses were collected through personal visits. This response rate is well above the recommended rate for an empirical study in operations management (Malhotra and Grover, 1998; O'Leary-Kelly and Vokurka, 1998). Nonetheless, according to Malhotra and Grover (1998) and Sahay *et al*. (2006) this response rate is adequate in India for this type of surveys.

4.3 Respondents' characteristics

Respondents are classified by organisational information; Table 4.1 presents the characteristics of the responded organisations.

Table 4. 1 Characteristics of respondents

Size of company		**Type of Industry**		**Number of employees**		**Investment limit in plant & machinery (In Million Rs)**	
Small	65	Automobiles and automobile components	131	<50	52	<2.5	0
Medium	317	Machine tools and metal products	169	50-100	102	2.5-50	65
		Electrical & Electronics goods	61	100-500	228	50-100	317
		Others (Food, Textile, Chemical, Rubber)	21	>500	0	>100	0

Sample size N=382

4.3.1 Size of firms

According to the Indian Ministry of Micro, Small and Medium enterprises (MSME, 2006), enterprises are classified as micro, small and medium based on their investment in plant and machinery. This classification is shown in Table 4.2. In this study the respondents are grouped in micro, small, medium and large enterprises. As shown in the Table 4.1 no respondent belongs to categories micro and large enterprises, hence this study includes only small and medium-sized enterprises. Based on the definition of MSME 65 respondents (17%) belong to small enterprises category and remaining 317 respondents (83%) belong to medium enterprises category.

Table 4. 2 Classification of enterprises in India

Classification	Manufacturing Enterprises*	Service Enterprises**
Micro	Upto Rs. 2.5 million	Upto Rs. 1 million
Small	Rs 2.5 million to 50 million	Rs.1 million to 20 million
Medium	Rs. 50 million to 100 million	Rs. 20 million to 50 million

* Investment limit in plant & machinery

** Investment limit in equipments

4.3.2 Respondents according to the number of employees

As shown in Table 4.1 the sample is also categorize on the basis of number of employees in the enterprise. The largest category within the sample represents those enterprises which had 100 to 500 employees. These represented almost 60 percent (228 enterprises) of the sample. Similarly, other clusters were respectively: less than 50 (52 enterprises 13%), and 50 to 100 (102 enterprises 27%) employees.

4.3.3 Respondents according to the type of enterprises

Small and Medium Enterprises in India manufacture a range of goods. Accordingly, the SME sector comprises of automobiles and automobile components manufacturers, machine tools and metal products manufacturers, electrical & electronics goods manufacturers and other products like food, textile, chemical and rubber producers. As indicated in Table 4.1, the maximum respondents are from the group machine tools and metal products manufacturers (169 enterprises, 44%). Likewise, other respondents include automobiles and automobile components manufacturers (131 enterprises, 34%), electrical & electronics goods manufacturers (61 enterprises, 16%) and others (21 enterprises, 6%).

4.4 Level of lean adoption in Indian SMEs

To measure the level of lean adoption in Indian SMEs, the approach adopted by Ghosh (2013) is followed. To assess degree of lean implementation, Ghosh (2013) surveyed 79 manufacturing firms in India. Author measured the level of adoption of seven lean practices. Level of adoption of the lean practices was asked on a 5 point Likert scale from the respondents with 1= no implementation and 5= complete implementation. The individual scores on each of the seven lean practices were summed up to calculate the total score for each respondent. The total score computed initially was out of 35. Consequently, it was extrapolated out of 100. At last, the respondents were ranked as per these scores to find the level of lean adoption.

Likewise, in this study to investigate the level of lean adoption in Indian SMEs, 10 lean practices are identified. Three to six questions are asked for each practice and total 43 questions were asked for 10 lean practices. A seven point Likert scale was used for each question according to the rule 1 = no implementation to 7 = complete implementation. The total score computed was 43×7= 301. This score was moderated to obtain the score out of 100. The respondents were ranked based on the score out of 100 to measure the degree of lean adoption. The results are illustrated in Table 4.3.

Table 4. 3 Level of lean adoption in Indian SMEs

Scores	Number of firms	%
70-100	Nil	0.00%
60-69	93	24.35%
50-59	112	29.32%
40-49	86	22.51%
30-39	59	15.44%
20-29	32	8.38%
0-19	Nil	0.00%

Note**: *N*=382**

It was noticed that none of the respondents scored more than 70 and less than 20. Majority of the respondents (76 percent) scored 40-69 and remaining 24 percent scored below 39. Therefore, it is evident from the data collected that the Indian SMEs are not significantly adopting lean practices to their enterprise. These findings are consistent with the other studies. For instance, Ghosh (2013) also found the same result that the adoption of lean practices in Indian industries was low. Similarly, Fliho *et al.,* (2016) concluded that the Brazilian SMEs adopted a limited number of lean practices and the level of adoption was also low.

4.5 Assessment of the important issues regarding lean adoption in Indian SMEs

This section demonstrates the various issues for lean adoption in Indian SMEs. These issues include: reasons of implementing lean, critical success factor for implementing lean and barriers to implement lean. In the following sections, these issues are dealt individually.

4.5.1 Reasons for implementing lean in Indian SMEs

After reviewing a plethora of literature, a scale which included five items was developed to identify the reasons for implementation lean in Indian SMEs. These reasons with literature support are shown in Table 4.4. The respondents were asked to rate the reasons on a seven point Likert scale (1= not important – 7= most important).

Table 4. 4 Reasons of implementing lean

Lean Implementation issue	No. of items	Items	Literature source	Cronbach's alpha
Reasons of implementing lean in SMEs	6	To eliminate of wastes To decrease production costs To improve quality To improve productivity To increase demand management efficiency To increase customer satisfaction	White *et al.* (1993), Taj (2008), Singh *et al.* (2010a)	.823

The reliability of the construct was tested by Cronbach's alpha test. The value of Cronbach's alpha was high enough (0.832) to confirm the reliability and internal consistency (Nunnally, 1982). Table 4.4 illustrates the ranks for reasons of implementing lean in SMEs. These ranks were derived in the basis of their mean scores.

Table 4. 5 Ranking of reasons of implementing lean

Reasons of Implementing Lean	Rank	Mean	Std. Deviation
To increase customer satisfaction	1	6.02	0.941
To decrease production costs	2	4.96	1.127
To improve quality	3	4.84	1.445
To improve productivity	4	4.82	1.319
To eliminate of wastes	5	4.20	1.424
To increase demand management efficiency	6	2.89	1.328

It is evident from Table 4.5 that most important reasons of implementing lean in Indian SMEs are 'to increase customer satisfaction', 'to decrease production costs', 'to improve quality', 'to improve productivity' and 'to eliminate of wastes'. To identify significantly important reasons of implementing lean, hypothesis H2 was proposed which stated that:

Hypothesis H1*: *Significant reasons of implementing lean in Indian SMEs are to increase quality, to reduce wastes, to increase customer satisfaction, elimination of wastes and to decrease production costs.

To test hypothesis H1, further statistical analysis was required. To find out the significant reasons of adopting lean manufacturing by Indian SMEs, t test was used. The observed median of each reason of implementing lean was compared with a mean score of 3 (α level of 0.05). The results are illustrated in Table 4.6.

Table 4. 6 T test for significant reasons of implementing lean

S. No.	Reason	Mean	t statistics	P
1	To increase customer satisfaction	6.02	457	0.000*
2	To decrease production costs	4.96	386	0.000*
3	To improve quality	4.84	364	0.001*
4	To improve productivity	4.82	232	0.001*
5	To eliminate of wastes	4.20	130.6	0.001*
6	To increase demand management efficiency	2.89	11.28	0.126

The reasons of implementing lean considered to be significantly important as reported by Indian SMEs include 'to increase customer satisfaction', 'to decrease production costs', 'to improve quality', 'to improve productivity' and 'to eliminate of wastes'. However, Indian

SMEs do not perceive that ‘to increase demand management efficiency’ is an important reason of implementing lean. Therefore, the hypothesis **H1** is accepted which states that

Significant reasons of implementing lean in Indian SMEs are ‘to increase customer satisfaction’, ‘to decrease production costs’, ‘to improve quality’, ‘to improve productivity’ and ‘to eliminate of wastes’.

4.5.2 Critical success factors for implementation lean in Indian SMEs

To identify the important critical success factors to implementing lean in Indian SMEs, a scale containing six items was developed after a comprehensive literature review. Critical success factors, which are cited frequently in the literature, are summarized in Table 4.7. Respondents were asked to rate the critical success factors of implementing lean on a seven point Likert scale.

Table 4. 7 Critical success factors of implementing lean

Lean Implementation issue	**No. of items**	**Items**	**Literature source**	**Cronbach's alpha**
Critical success factors to implement lean	6	*Management Commitment and Leadership* *Organisational culture* *Training and skills* *Employee involvement* *Communication* *Financial capability*	Achanga *et al.* 2006 ; Panizzolo *et al.* 2012; Dora *et al.* 2013 ; Dora *et al.* 2015 ; Hu *et al.* 2015	.703

Value of Cronbach’s alpha (0.703) confirmed that the scale is reliable and have high internal consistency (Nunnally, 1982). Table 4.8 illustrates mean scores of challenges and their ranks (based on mean scores) while implementing lean in Indian process industries. It is evident from Table 4.8 that most important challenges of implementing lean in Indian process industries are ‘lack of training’, ‘to arrange lean experts’ and ‘to identify techniques for setup time reduction’.

Table 4. 8 Ranking of critical success factors of implementing lean in Indian SMEs

Critical success factors to implement lean	Rank	Mean	Std. Deviation
Management Commitment and Leadership	1	6.38	1.154
Organisational culture	2	5.22	1.396
Training and skills	3	5.20	1.358
Employee involvement	4	4.96	1.429
Communication	5	4.84	1.413
Financial capability	6	4.73	1.268

To examine significantly important critical success factors to implement lean in Indian SMEs the hypothesis H2 was proposed:

***Hypothesis H2*: *Significant critical success factors of implementing lean in Indian SMEs are management commitment and leadership, organisational culture, training and skills, employee involvement, communication and financial capability*.**

Further statistical analysis was carried out to test H3. To find out the significantly important critical success factors of adopting lean manufacturing by Indian SMEs, t test was used. The observed mean of each item was compared with a mean score of 4 (α level of 0.05). The results are illustrated in Table 4.9. Results show that significantly important critical success factors to implement lean, as reported by Indian SMEs, are '*management commitment and leadership', 'organisational culture', 'training and skills', 'employee involvement', 'communication', and 'financial capability'.*

Table 4. 9 T test for significant critical success factors to implementing lean in Indian SMEs

Challenges	Mean	t statistics	P
Management Commitment and Leadership	6.38	578.5	0.004*
Organisational culture	5.22	559.0	0.011*
Training and skills	5.20	400.0	0.003*
Employee involvement	4.96	259.5	0.000*
Communication	4.84	232.5	0.001*
Financial capability	4.73	243.0	0.002*

* significant at 0.05 level

Therefore, the hypothesis **H2** is accepted which states that:

"Significant critical success factors to implement lean in Indian SMEs are 'management commitment and leadership', 'organisational culture', 'training and skills', 'employee involvement', 'communication', and 'financial capability'."

4.5.3 Barriers to implement lean in Indian SMEs

To investigate the important lean implementation barriers (LIBs) in Indian SMEs, a scale containing seven items was developed after a comprehensive literature review. The frequently mentioned LIBs synthesized from literature are summarized in Table 4.10. Respondents were asked to rate the LIBs to implement lean, on a seven point Likert scale.

Table 4. 10 Barriers to implement lean

Lean Implementation issue	No. of items	Items	Literature source	Cronbach's alpha
Barriers to implement lean	10	Lack of management commitment and leadership Organisational culture Lack of communication Lack of resources Resistant to change Lack of Employee involvement Lack of training and skills Lack of understanding lean benefits (measuring benefits) Backsliding to old methods Lack of supplier involvement	Jadhav *et al.* 2014; Dora *et al.* 2015; Hu *et al.* 2015; Abolhassani *et al.* 2016	.760

Value of Cronbach's alpha (0.760) confirmed that the scale is reliable and have high internal consistency (Nunnally, 1982). Table 4.11 illustrates mean scores of importance of LIBs and their ranks (based on mean scores) while implementing lean in Indian SMEs.

Table 4. 11 Ranking of barriers to implement lean

Barriers to implement lean	Rank	Mean	Std. Deviation
Lack of management commitment and leadership	1	6.26	1.117
Lack of resources	2	6.20	0.963
Lack of communication	3	6.11	0.825
Organisational culture	4	5.84	1.093
Lack of understanding lean benefits (measuring benefits)	5	5.56	0.682
Lack of Employee involvement	6	4.82	1.186
Lack of training and skills	7	4.61	1.134
Resistant to change	8	4.44	0.854
Backsliding to old methods	9	4.32	0.921
Lack of supplier involvement	10	4.28	0.872

It is evident from Table 4.11 that most important LIBs in Indian SMEs are 'lack of management commitment and leadership', 'lack of resources', 'lack of communication', 'organisational culture', 'lack of understanding lean benefits', 'lack of employee involvement', and 'lack of training and skills'. To examine the significant LIBs in Indian SMEs hypothesis H3 was proposed. H3 was stated as:

Hypothesis H3: Significant barriers while implementing lean in Indian SMEs are lack of management commitment and leadership, organisational culture, lack of communication, lack of resources, resistant to change, lack of employee involvement, lack of training and skills, lack of understanding of lean benefits, backsliding to old methods, and lack of supplier involvement.

Further statistical analysis was carried out to test H3. Therefore, to find out the significantly important LIBs in Indian SMEs, t test was used. The observed mean of each item was compared with a median score of 4 (α level of 0.05). The results are illustrated in Table 4.12. Results of Table 4.12 show that significantly important LIBs to implement lean, as reported by Indian SMEs are lack of management commitment and leadership, organisational culture, lack of communication, lack of resources, resistant to change, lack of employee involvement, lack of training and skills, lack of understanding of lean benefits, backsliding to old methods, and lack of supplier involvement.

Table 4. 12 T test for significantly important barriers to implement lean in Indian SMEs

Barriers to implement lean	Mean	t Statistics	p
Lack of management commitment and leadership	6.26	625.0	0.000*
Lack of resources	6.20	598.0	0.000*
Lack of communication	6.11	545.5	0.000*
Organisational culture	5.84	482	0.000*
Lack of understanding lean benefits (measuring benefits)	5.56	444	0.000*
Lack of Employee involvement	4.82	363	0.000*
Lack of training and skills	4.61	326	0.000*
Resistant to change	4.44	292	0.000*
Backsliding to old methods	4.32	279	0.000*
Lack of supplier involvement	4.28	256	0.000*

* significant at 0.05 level

Therefore, the hypothesis **H3** is accepted which states that

"Significantly important LIBs in Indian SMEs are lack of management commitment and leadership, organisational culture, lack of communication, lack of resources, resistant to change, lack of employee involvement, lack of training and skills, lack of understanding of lean benefits, backsliding to old methods, and lack of supplier involvement."

4.5.4 Overview of implementation of lean practices

Ten performance improvement practices were extracted from extant literature, which are frequently mentioned in literature as lean practices. Three to six questions are asked for each practice and total 43 questions were asked for 10 lean practices. A seven point Likert scale was used for each question according to the rule 1 = no implementation to 7 = complete implementation. Reliability analysis of scale to measure extent of implementation of lean practices is presented in Table 4.13.

Table 4. 13 Reliability analysis of scale of implementation of lean practices

Lean practices	Variable	Literature source	Cronbach's alpha
Customer involvement	We are in close contact with our customers.	Shah and Ward (2003); Hofer et al. (2012); Filho et al. (2016); Panwar et al. (2018)	0.723
	Customers give feedback on quality and delivery performance.		
	Customers are actively involved in current and future product offerings.		
	Customers frequently share demand information.		
Employee involvement	Shop floor employees are actively involved in problem solving.		0.782
	Shop floor employees are actively involved in process improvements.		
	Shop floor employees regularly provide suggestions for improvement.		
	Shop floor employees undergo cross-functional training.		
Supplier involvement	We give our suppliers feedback on quality and delivery performance.		0.723
	We strive to establish long-term relationship with our suppliers.		
	Our key suppliers are located in close proximity to our plant.		
	We take active steps to reduce the number of suppliers in each category.		
Pull system	Production is pulled by shipment of finished goods.		0.802
	Production at workstations is pulled by the demand of the next station.		
	We use Kanban, squares or containers of signals for production control.		
	We use a pull system to control the production rather than a schedule prepared in advance.		
5S	Only the materials which are actually needed are present in the work area.		0.799
	Only tools and hand tools which are needed are present in the work area.		
	Locations for all production materials are clearly marked out and the materials are stored in the correct locations. Areas for WIP (work-in-process parts) are clearly marked.		
	Work areas, storage areas, aisles machines, tools, equipment and offices are clean/neat and free of safety hazards.		
	Regularly scheduled housekeeping tours and periodic self-		

	assessments (5S audits) are conducted.		
Total Productive Maintenance	We maintain all our equipment regularly.		0.729
	We maintain records of all equipment maintenance activities.		
	We ensure that machines are in high state of readiness for production at all the time.		
	Operators are trained to maintain their own machines.		
Statistical process control	Charts showing defects are used as tools on the shop floor.		0.699
	We use diagrams like cause & effects (fishbone) to identify causes of quality problems		
	We conduct process capability studies before product launch.		
	We use statistical techniques to reduce process variance.		
Single minute exchange of dies	We are working to lower set-up time in our plant		0.836
	We have short set-up times for equipment in our plant		
	Operators perform their own machines set-ups.		
	Operators are trained on machine set-up activities.		
	We emphasize the need to place all tools in a convenient area to the operator.		
Visual management	Equipment are identified with signages		0.926
	Process parameters are displayed on the shop floor.		
	Manufacturing performance is displayed on the shop floor.		
Production levelling	We mix production on the same machines and equipment..		0.733
	We emphasize the need for an accurate forecast to reduce variability in production.		
	Each product is produced in a relatively fixed quantity per production period.		
	We emphasize the need to equalize workloads in each production process.		
	We produce by repeating the same combination of products from day to day.		
	We always have some quantity of every product model to respond to variation in customer demand.		

Values of Cronbach's alpha (0.699-0.926) confirmed that the scales are reliable and have high internal consistency (Nunnally, 1982). Table 4.14 illustrates mean scores of lean practices and their ranks (based on mean scores) in Indian SMEs.

Table 4. 14 Ranking of lean practices being used by Indian SMEs

Lean Practices	Mean	Rank
Customer involvement	5.1125	1
Total productive maintenance	4.9275	2
5S	4.662	3
Production leveling	4.6	4
Statistical process control	4.57	5
Employee involvement	4.3975	6
Single minute exchange of dies	3.836	7
Pull system	3.56	8
Visual management	3.15	9
Supplier involvement	2.47	10

It is evident from Table 4.14 that most important lean practices in Indian SMEs are Customer involvement, Total productive maintenance, 5S, Production levelling, Statistical process control, Employee involvement, Single minute exchange of dies and Pull system. To examine the significantly important lean practices in Indian SMEs hypothesis H14 was proposed. H4 was stated as:

Hypothesis H4: Significantly high used lean practices are Customer involvement, Total productive maintenance, Supplier involvement, 5S, Production levelling, Visual Management, Statistical process control, Employee involvement, Single minute exchange of dies, Pull system.

Further statistical analysis was carried out to test H4. Therefore, to find out the significantly important lean practices in Indian SMEs, t test was used. The observed mean of each item was compared with a median score of 4 (α level of 0.05). The results are illustrated in Table 4.15. Results of Table 4.15 show that significantly important lean practices, as reported by Indian SMEs are Customer involvement, Total productive maintenance, 5S, Production levelling, Statistical process control, Employee involvement, Single minute exchange of dies and Pull system.

Table 4. 15 T test for significantly important lean practices in Indian SMEs

Lean Practices	Mean	t Statistics	p
Customer involvement	5.1125	415	0.002*
Total productive maintenance	4.9275	359	0.004*
5S	4.662	322	0.002*
Production leveling	4.6	318	0.009*
Statistical process control	4.57	304	0.012*
Employee involvement	4.3975	279	0.013*
Single minute exchange of dies	3.836	168	0.018*
Pull system	3.56	102	0.021*
Visual management	3.15	12.6	0.434
Supplier involvement	2.47	83	0.028*

* significant at 0.05 level

Therefore, the hypothesis **H4** is accepted which states that
"Significantly important LIBs in Indian SMEs are *Customer involvement, Total productive maintenance, 5S, Production levelling, Statistical process control, Employee involvement, Single minute exchange of dies and Pull system*."

4.6 Conclusion

This chapter discussed the findings of the survey. All the respondents belong to small and medium-sized enterprises. The first assignment was to measure the degree of lean adoption in Indian SMEs. It was detected that only 24.35% have employed lean to a significant level, though, 51.83% respondents have applied lean to a moderate level. Hence, it is noted that most of the SMEs who have adopted lean have not implemented lean to a significant level. In addition, these findings are in line with earlier findings. Panwar *et al.*

(2015) and Garza-Reyes *et al.* (2012) also found that adoption of lean is low in Indian industries. In international scenario, earlier studies also suggest that adoption of lean in SME sector is low. (Fliho *et al.* 2016; Bhasin 2012). Concept of lean is relatively new for Indian industries. Its adoption in India has started very recently (Ghosh, 2013). Therefore, understanding of the concept is still low. Furthermore, it was evolved and popularised in large enterprises. Therefore, managers in SMEs still found it difficult to adapt lean tools and techniques to suit their requirements. Hence, lean is still not widespread in Indian SMEs.

Subsequent objective of this research was to gain knowledge and insights into important issues regarding lean implementation in Indian SMEs. These issues included; reasons of implementing lean, critical success factors of implementing lean, and barriers to implement lean. Indian SMEs who have adopted 'lean', perceive 'customer satisfaction' as the foremost reason for implementing 'lean'. Garza-Reyes et al. (2012) also assert that most important reason of adopting lean by Indian manufacturing industries was 'customer satisfaction'. Possibly the cutthroat competition and ever demanding customer has forced Indian SMEs to give emphasis to customer satisfaction. Another major reason of implementing lean in Indian SMEs is 'to decrease production cost'. In today's globalize market conditions, cost effectiveness is the key to remain in competition. Other significant reasons of lean implementation in SMEs were 'to improve quality', 'to improve productivity' and 'to eliminate of wastes'.

According to the results of the current study, the most prominent critical success factor was 'management commitment and leadership'. Achanga *et al.* (2006) also found the same results. It seems to be obvious because success of each initiative in any type of organisation majorly depends on the commitment of the top executives and the leadership skills. Other significant critical success factors to implement lean in SMEs were organisational culture, training and skills, employee involvement, communication and financial capability.

Indian SMEs perceive 'lack of management commitment and leadership', 'lack of resources' and 'lack of communication', as the prominent barriers to implement lean. These findings support previous findings (Jadhav et al. 2014; Dora et al. 2015). Lean implementation strictly requires consistent involvement, encouragement, and supervision of the top management (Panizzolo *et al.* 2012; Hu *et al.* 2015; Abolhassani *et al.* 2016). Top management has to set vision, strategy, goals and a direction to keep the project (Jadhav *et al.*

2014). A proper communication within the organisation and between its stakeholders is the key success factor for lean implementation (Scherrer-Rathje *et al.*, 2009; Timans *et al.* 2012). According to Eswaramoorthi *et al.* (2011) lack of time, workforce and funds have been attributed for the meagre adoption of lean in SMEs.

Lean practices such as Customer involvement, Total productive maintenance, 5S, Production levelling, Statistical process control, Employee involvement, Single minute exchange of dies and Pull system are more formally and regularly used in Indian SMEs. However, lean practices such as Supplier involvement and Visual management are used by very low percentage of respondents. The relationship between performance improvement and lean practices is discussed in more details in the next chapter, in which the relationship is tested using statistical tests.

Chapter 5

The Impact of Lean Practices on the Operational & Financial Performance

5.1 Introduction

Toyota developed the Toyota Production System (TPS) in Japan. This concept evolved into lean manufacturing (Krafcik, 1988) in the USA and then diffused to other developed economies. Although numerous studies have reported the significant benefits of lean adoption in large enterprises (Shah and Ward 2003; Shah and Ward 2007; Belekoukias et al. 2014; Bevilacqua et al. 2017), a lot of scepticism still remains regarding its impact in small and medium-sized enterprises (SMEs). The benefits of lean adoption need to be fully considered and evaluated in SMEs. Similarly, to lean research in general, lean adoption in SMEs has recently gained attention in developing countries such as India, where SMEs account for 45% of exports, 45% of the total manufacturing output and employment to over 80 million people (MSME 16).

A few lean implementation case studies in SMEs can be found in the literature (Kumar *et al.* 2006; Upadhye *et al.* 2010; Panizzolo *et al.* 2012; Arya and Jain 2014; Vinodh *et al.* 2014; Arya and Choudhary 2015; Gupta and Jain 2015) principally concentrating on the level of implementation and the development of presentational and analytical frameworks. However, the literature concerning the impact of lean adoption on operational and financial performance in SMEs is limited. Thus, there is a strong need for further investigation into the relationship between lean implementation operational performance and financial performance in SMEs. Here, in this research, a twofold attempt is made to fill the gap by first assessing the degree of adoption of lean practices in SMEs and, subsequently, analyzing the impact of lean practices on the operational and financial performance of SMEs. A survey of 382 Indian SMEs was carried out, and the data was analyzed using a Structural Equation Modelling (SEM) approach. The critical finding is 'the lean practices are positively associated with lean adoption and lean has positive impact on operational and economic performance.' The direct relationship between operational and economic performance is also positive and significant.

From a comprehensive review of present literature and findings from initial stages of the research, a model of the relationship between lean practices and performance improvement has been developed and tested in this chapter. First objective of the present research has been explored in the previous chapter. In the present chapter, second objective is discussed. The second objective was to determine causal relationship between lean practices and performance improvement in Indian process industries.

5.2 Missing values analysis

Missing value analysis procedure was used to identify missing values and patterns of missing values in the data. It helps in deciding how the missing values are to be treated. This analysis is used to examine the missing data and take a decision of not inputting means to missing values. In present study data, no missing value is found.

5.3 Outliers

In this study Mahalanobis distance (D2) which is the distance of a particular case from the centroid of remaining cases was used as a measure of outliers. The point created by the means of all variables is called centroid. Hair et al. (2006) suggested that critical level for the measure D2/Df should be less than 3 or 4 in large samples (more than one hundred). In this study no evidence was found of outliers when tested with SPSS 22.0 software package.

5.4 Non Responses bias

The non-response bias test was carried out to assess whether there is any significant difference between the early and late respondents of the returned survey. In this context, the early and late respondents of the returned survey were compared using independent test for all variables of the study. The comparison was made based on the assumption that the late respondents were considered as non-respondents, as suggested by Armstrong and Overton (1977) and Lambert and Harrington (1990). In this study, a total of 345 survey respondents were divided into early (n = 155, 44.9 %) and late (n = 190, 55.1%) respondents.

By using independent t-test analysis, the comparison was made to identify any significant difference of the mean values of the nine constructs of the study. The results of the comparison between early and late respondents was insignificant for all variables at the 5 % significance level, thus suggesting that the non-response bias was not present.

5.5 Factor analysis

Factor analysis is used to identify number of constructs that might be used to represent relationship among set of variables (Mitra & Datta, 2014). It is primarily used for dimension reduction and factor extraction. The purpose of factor extraction is to extract factor or construct, i.e. the underlying construct that describes a set of items.

In the present research, factor analysis is used to dimension reduction and identification of research constructs related to Lean practices and performance measures. For factor analysis, normality, linearity and homogeneity of the sample are assumed. The ratio of respondent-to- variables exceeds the minimum value of 5 (Mitra & Datta, 2014). There exists significant correlation among many of the variables. Partial correlations among most of the variables are 0.58 or less. Originally, 43 items were used to gain the insight to respondent's perception. exploratory factor analysis (EFA) is recognised as a suitable tool for item reduction and to establish the unidimensionality of the variables. The Principal Components Analysis (PCA) with Varimax rotation was used and ten factors (lean practices) extracted with eigenvalues greater than one explaining 66 percent of the variance.

5.5.1 KMO and Bartlett's Test

Field (2009), recommends that before running the factor analysis, variables should be analysed for sample adequacy through Kaiser-Mayer-Olkin (KMO) measures and Bartlett's test of sphericity. Therefore, the first step running factor analysis was to carry out KMO test with sample adequacy and Bartlett's test of sphericity. KMO varies from 0 to 1 and KMO overall should be 0.60 or higher to proceed with factor analysis. In the present research, Kaiser-Mayer-Olkin (KMO) statistics was found to be 0.756 as shown in Table 5.1.

Bartlett’s test of sphericity examines the correlation matrix. In the present study, the Bartlett’s test of sphericity was significant (0.000) as shown in Table 5.1. Thus both the test Kaiser-Mayer-Olkin (KMO) (0.756) and Bartlett’s test (Sig. 0.000) indicates that the data is suitable for factor analysis.

Table 5. 1 KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.756
Bartlett's Test of Sphericity	Approx. Chi-Square	9441.426
	df	1770
	Sig.	.000

5.5.2 **Eigen value**

Eigen values are the sum of square values of factor loadings relating to factors. According to Costello (2009), the factor has low Eigen value, it means that it is contributing little to the explanation of variance in the variables and may be ignored and replaced with factors that are more important. Table 5.2 illustrates the Eigen values associated with each factor. It is evident from Table 5.2, that first few constructs explain relatively large amount of variance whereas subsequent factors explain only small amount of variance. According to Kaiser’s rule, all items having Eigen value less than one should be dropped.

5.5.3 **Factor Loading and Rotation**

It is possible to see items with large loading on several of the un-rotated factors, which can make interpretation difficult. In such cases, it can be helpful to examine a rotated solution. The varimax rotation approach simplifies the structure to maximum possible extent. It maximizes the sum of variance of the required loading of the factor matrix. According to Hair *et al.* (2006), only the items with factor loadings greater than 0.5 were considered for the further analysis. Initial factor rotation was applied to check the cross-loadings by removing them for better validity.

Table 5.3 presents the varimax factor rotated component matrix. The loadings of manifest variables for each construct were greater than 0.5 which confirm the convergent validity. Since none of the manifest variable have loading greater than 0.4 on two or more constructs; it legalizes the discriminant validity.

Table 5. 2 Extracted sum of squared loading

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	5.868	9.780	9.780	5.868	9.780	9.780	3.450	5.750	5.750
2	4.240	7.067	16.846	4.240	7.067	16.846	2.893	4.821	10.571
3	3.396	5.660	22.506	3.396	5.660	22.506	2.888	4.813	15.384
4	2.974	4.956	27.462	2.974	4.956	27.462	2.870	4.784	20.168
5	2.812	4.687	32.149	2.812	4.687	32.149	2.866	4.777	24.944
6	2.615	4.358	36.507	2.615	4.358	36.507	2.768	4.613	29.557
7	2.491	4.151	40.658	2.491	4.151	40.658	2.594	4.324	33.880
8	2.265	3.775	44.433	2.265	3.775	44.433	2.586	4.310	38.191
9	2.025	3.374	47.808	2.025	3.374	47.808	2.558	4.263	42.454
10	1.895	3.159	50.966	1.895	3.159	50.966	2.409	4.015	46.470
11	1.715	2.858	53.824	1.715	2.858	53.824	2.322	3.870	50.339
12	1.620	2.700	56.524	1.620	2.700	56.524	2.278	3.796	54.135
13	1.512	2.520	59.045	1.512	2.520	59.045	2.178	3.630	57.765
14	1.394	2.323	61.368	1.394	2.323	61.368	2.162	3.603	61.368
15	.961	1.602	62.970						
16	.942	1.571	64.541						
17	.910	1.517	66.058						
18	.890	1.483	67.541						
19	.866	1.444	68.985						
20	.816	1.361	70.346						
21	.801	1.336	71.681						
22	.721	1.201	72.882						
23	.709	1.182	74.064						
24	.689	1.148	75.212						
25	.678	1.130	76.342						
26	.670	1.117	77.459						
27	.634	1.056	78.515						
28	.608	1.013	79.528						
29	.588	.980	80.508						
30	.582	.970	81.478						
31	.571	.951	82.429						
32	.534	.890	83.319						
33	.530	.883	84.202						
34	.521	.868	85.070						
35	.508	.846	85.917						
36	.497	.829	86.745						
37	.488	.813	87.558						
38	.474	.790	88.349						
39	.472	.787	89.136						
40	.444	.740	89.875						
41	.422	.703	90.579						
42	.418	.696	91.275						
43	.405	.676	91.950						

Table 5. 3 Varimax factor rotated component matrix

	CI	SMED	5S	VM	SI	EI	TPM	PS	PL	SPC
CI_1	.713*									
CI_2	.721*									
CI_3	.740*									
CI_4	.736*									
EI_1						.715*				
EI_2						.736*				
EI_3						.743*				
EI_4						.839*				
SI_1					.631*					
SI_2					.582*					
SI_3					.534*					
SI_4					.522*					
PS_1								.734*		
PS_2								.794*		
PS_3								.829*		
PS_4								.743*		
@5S_1			.749*							
@5S_2			.785*							
@5S_3			.712*							
@5S_4			.753*							
@5S_5			.753*							
TPM_1							.723*			
TPM_2							.742*			
TPM_3							.762*			

TPM_4							.824*			
SPC_1										.705*
SPC_2										.725*
SPC_3										.797*
SPC_4										.748*
SMED_1		.757*								
SMED_2		.760*								
SMED_3		.780*								
SMED_4		.721*								
SMED_5		.812*								
VM_1				.621*						
VM_3				.516*						
VM_2				.529*						
PL_1									.724*	
PL_2									.720*	
PL_3									.712*	
PL_4									.780*	
PL_5									.723*	
PL_6									.702*	
*Higher loading										

5.5.4 Internal consistency analysis of research constructs

To measure the internal consistency, the most preferred method is to compute reliability of the constructs. It usually measures through the reliability coefficient i.e. Cronbach's alpha. The value of alpha varies from 0 to 1 and higher values indicate the higher reliability. The most preferred value of Cronbach's alpha is 0.7 (Flynn et al., 1990).

Table 5.4 illustrates various higher level of constructs, number of items in them and the value of Cronbach's alpha for each construct. High value of Cronbach's alpha for each factor confirms the reliability of the instrument. In the research, value of Cronbach's alpha range from 0.718 to 0.832. On the basis of Cronbach's alpha coefficient, the study confirmed the ten factors of lean thinking practices.

Table 5. 4 Internal consistency of constructs (Cronbach's alpha)

S.No.	Name of construct	Number of items	Cronbach's alpha
1	Customer involvement (CI)	4	0.726
2	Employee involvement (EI)	4	0.784
3	Supplier involvement (SI)	4	0.728
4	Pull system (PS)	4	0.809
5	5 S	5	0.796
6	Total productive maintenance (TPM)	4	0.722
7	Statistical process control (SPC)	4	0.718
8	Single minute exchange of dies (SMED)	5	0.832
9	Visual management (VM)	3	0.736
10	Production levelling (PL)	6	0.774

5.5.5 Validities

Validity is the extent to which two measures or set of measures correctly represent the concept of study i.e. the degree to which it is free from any systematic or non-random error (Hair et al. 2013). Three type of validity are usually considered in literature: (i) Content validity, (ii) Criteria related validity and (iii) Construct validity.

5.5.5.1 Content validity

Content validity refers to the extent to which a measure represents all factors of a given construct. Content validity cannot be determined statistically. It can be determined by experts (Flynn et al. 1990). Since the measurement items were selected after a comprehensive literature review, through evaluation by academicians and industry professionals followed by opinions of experts those who have wide experience in the field of operations management. Hence the scale represents the content validity.

5.5.5.2 Criteria related validity

The basic idea of criteria related validity is to check the performance of the measure against some criteria. Traditionally, criteria related validity is evaluated by examining the correlations of the different construct with one or more sustainable performance or manufacturing competitiveness. This investigates the empirical relationship between the scores of test instrument Table 5.5 illustrates the bivariate correlation analysis between the constructs and it can be seen that for both relevant criteria the correlation is high. Hence the scale represents the criteria related validity.

Table 5. 5 Bi-variate Correlation between constructs

	CI	EI	SI	PS	5S	TPM	SPC	SMED	VM	PL
CI	1									
EI	0.52**	1								
SI	0.18*	0.12	1							
PS	0.28**	0.19*	0.17*	1						
5S	0.36**	0.37**	0.08	0.31**	1					
TPM	0.57**	0.39**	0.19*	0.36**	0.38**	1				
SPC	0.52**	0.42**	0.12	0.29**	0.39**	0.56**	1			
SMED	0.38**	0.23**	0.19*	0.42**	0.41**	0.23**	0.25**	1		
VM	0.34**	0.09	0.18*	0.27**	0.19*	0.16*	0.17*	0.16*	1	
PL	0.52**	0.26**	0.17*	0.28**	0.38**	0.55**	0.58**	0.27**	0.25**	1

** Correlation is significant at the level of 0.01
* Correlation is significant at the level of 0.05

5.5.5.3 Construct validity

To estimate that all items in scale measures the same construct, construct validity is carried out. It was estimated using principal component analysis. The matrices of different factors illustrated that they were uni-factorial with Eigen values greater than 1.

Therefore, the result of present study indicated fairly good construct validity for the developed scales. Construct validity is illustrated in Table 5.6. KMO measure of sample adequacy is >0.6 for all items of each constructs with Eigen value greater than 1, therefore the items for each construct are suitable for factor analysis.

Table 5. 6 Summery of factor matrices for each higher level constructs

	KMO	% variance	Eigen value
Customer involvement (CI)	0.760	54.912	2.196
Employee involvement (EI)	0.765	60.627	2.425
Supplier involvement (SI)	0.735	54.780	2.191
Pull system (PS)	0.784	63.081	2.523
5 S	0.837	55.594	2.780
Total productive maintenance (TPM)	0.746	55.403	2.216
Statistical process control (SPC)	0.740	52.916	2.117
Single minute exchange of dies (SMED)	0.843	61.575	3.079
Visual management (VM)	0.765	87.144	2.614
Production levelling (PL)	0.729	43.733	2.624

5.6 Structural equation model (SEM)

SEM is a family of statistical models that seek to explain the relationship among multiple variables. It examines the structure of interrelationships expressed in a series of equations, similar to a series of multiple regression equations. These equations depict all the relationship among constructs (dependent and independent variables) involved in the analysis (Hair et al. 2013). A SEM model includes measurement model and structural model.

In this research, Maximum likelihood (ML) estimation approach was used. The ML approach is the iterative estimation procedure that estimates based on maximizing the probability (likelihood) that the observed co-variances are drawn from the population assumed to be the same as that reflected in the coefficient estimates (Kline, 2015). In a literature review, Shah and Goldstein (2006) found that majority of the studies (68.9 percent) in the operations management field used ML estimation approach. The measurement model developed by EFA was further assessed using CFA. A twostep approach was adopted; initially the fitness of the measurement model was evaluated and then the structured model was tested. The convergent and discriminant validity can be tested from the measurement model whereas; the structural model offers the evaluation of predictive validity.

To evaluate the measurement model and structural model, fit indices like χ^2, χ^2 /df (df=degree of freedom), normal fit index (NFI), comparative fit index (CFI), goodness of fit (GFI), adjusted goodness of fit (AGFI), root mean square residual (RMR), and root mean square of error approximation (RMSR) were used. A good fit model should have the values of GFI, AGFI, NFI, and CFI close to one or greater than 0.9 and the values of RMSEA 0.5 or less (Byrne 2013; Kline 2015). According to Schermelleh-Engel *et al.* (2003), the value of RMR between 0.05 and 0.10 is considered good. In this study, all the values of fitness indices were satisfactory for eight out of ten constructs, whereas for remaining two constructs supplier involvement and visual management the fitness indices were not acceptable.

5.6.1 **Confirmatory factor analysis**

The term confirmatory factor analysis (CFA) is used to refer to the analysis of measurement of construct or model. CFA approach attempt to test the viability of selected research model and constructs, which are usually based on the theory or previous experience or as the research objectives, and to examine whether or not existing data are consistent with a proposed research model. The study assesses two types of measurement models namely the one factor congeneric models and multifactor models. One factor measurement model is used to assess item's reliability, construct validity while multifactor measurement models are more inclined to analyze the Discriminant validity of the individual scales in the construct. Together these models provide the detailed picture of the underlying constructs and associated items in the constrained model using the statistical test.

To develop measurement model for Research constructs, the items were extracted from the literature, expert opinion and industry professionals. A seven point Likert scale survey questionnaire was developed and data was collected as discussed in chapter 3. Total 382 responses were collected from the Indian SMEs. Furthermore, CFA was performed to create a measurement model. In this study AMOS 22.0 software with maximum likelihood estimation (MLE) method was used. A series of procedures were applied to verify that all the proposed measurement items represent the construct and constructs represent the model.

5.6.1.1 One factor congeneric model

One factor congeneric measurement model is a model of single latent construct (unobserved variables) which is measured by several items (observed variables) (Anderson and Gerbing 1988). Congeneric measurement models are more beneficial in offering precise tests convergent and discriminant validity of construct measurement. This study contains twelve constructs.

Various indices are considered based on goodness of fit for model viz. chi square ($\chi 2$) (CMIN), goodness of fit index (GFI), adjusted goodness of fit index (AGFI), normed fit index (NFI), comparative fit index (CFI) and root mean square residual (RMR) for covering the divers' statistical aspects. The very common recommendation to report the fit indices proposes the chi square ($\chi 2$) and root mean square error of approximation (RMSEA) tests.

5.6.1.1.1 Measurement model for Customer Involvement

The construct of Customer Involvement (CI) contains four items (observed variables) names CI1. CI2, CI3 and CI4. The measurement model is found statistically significant as shown in Figure 5.1 and Table 5.7 & 5.8. The chi square ($\chi 2$) value of model is 0.436 with a p-value 0.804 and degree of freedom (df) is 2, which could indicate the best fit of the data. The other model indices are ($\chi 2$)/df = 0.218, GFI =0.999, AGFI = 0.997, RMR = 0.004, NFI = 0.998, CFI = 1.000 and RMSEA = 0.000 shows the perfect acceptable model fit for further analysis. The factor loading of each variable is above 0.591 (standardize) which support the construct validity of construct CI.

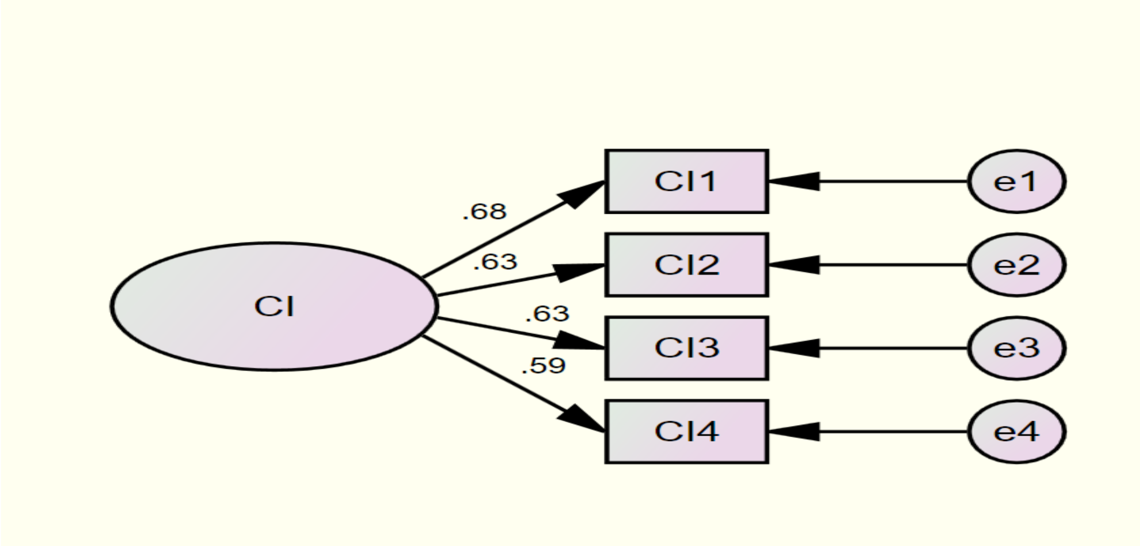

Figure 5. 1 Measurement model for Customer Involvement (CI)

Table 5. 7 Model fit indices for Customer Involvement (CI)

Model fit indices	Value of the model
(χ^2)/df	0.218
GFI	0.999
AGFI	0.997
RMR	0.004
NFI	0.998
CFI	1.000
RMSEA	0.000

df= 2, χ^2= 0.436 p-value= 0.804

Table 5. 8 Regression weights for Customer Involvement (CI)

			Estimate (Unstandardized)	Estimate (Standardized)	Standard Error (S.E.)	Critical Ratio (C.R.)	P
CI1	<---	CI	0.881	0.683	0.100	8.837	***
CI2	<---	CI	1.000	0.632			
CI3	<---	CI	0.909	0.627	0.106	8.545	***
CI4	<---	CI	0.935	0.591	0.113	8.260	***

***P≤0.001

5.6.1.1.2 Measurement model for Employee Involvement

The construct of Employee involvement (EI) contains four items (observed variables) names EI1, EI2, EI3 and EI4. The model was found statistically significant as shown in Figure 5.2 and Table 5.9 & 5.10.

The chi square ($\chi2$) value of model is 1.837 with a p-value 0.175 and degree of freedom (df) is 1 which indicates the best fit of the data. The other model indices are ($\chi2$)/df = 1.837, GFI = 0.998, AGFI = 0.976, RMR = 0.006, NFI = 0.992, CFI = 0.996 and RMSEA = 0.047 shows the perfect acceptable model fit for further analysis. The factor loading of each variable is above 0.469 (standardize) which support the construct validity of construct EI.

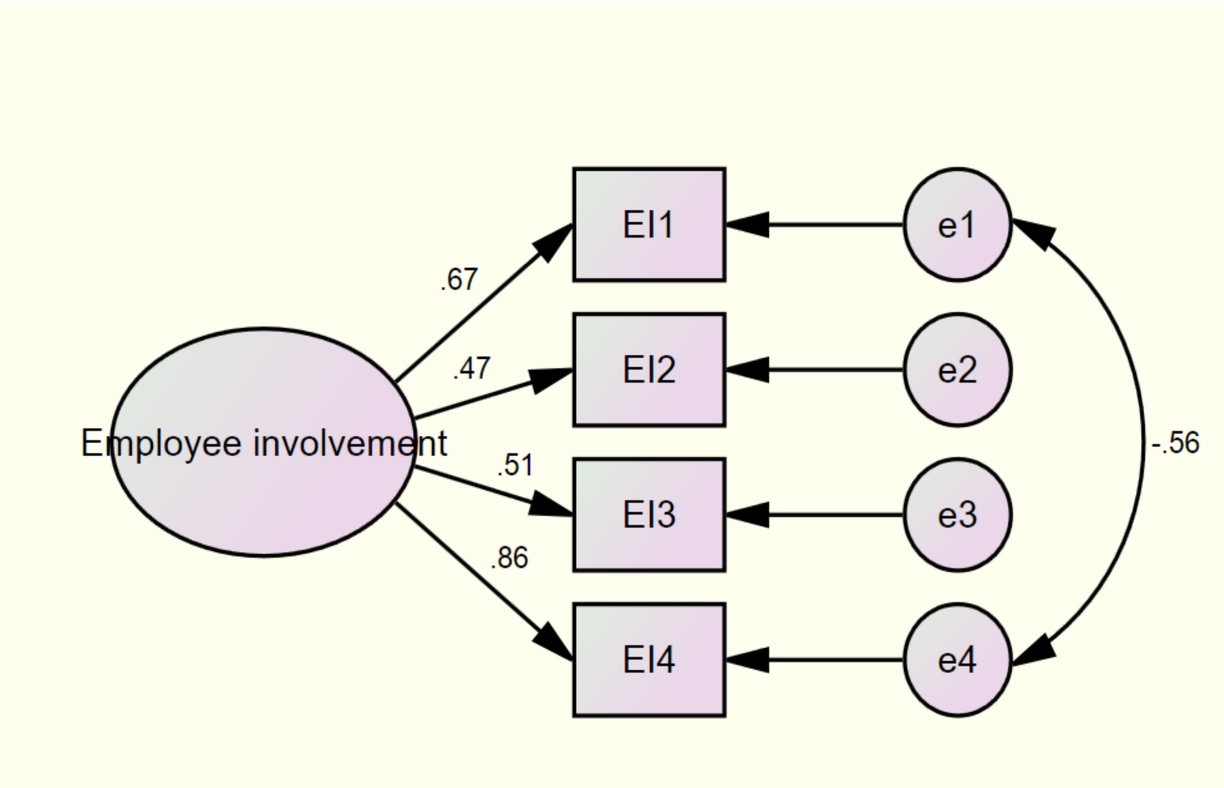

Figure 5. 2 Measurement model for Employee Involvement (EI)

Table 5. 9 Model fit indices for Employee Involvement (EI)

Model fit indices	Value of the model
(χ^2)/df	1.837
GFI	0.998
AGFI	0.976
RMR	0.006
NFI	0.992
CFI	0.996
RMSEA	0.047

df= 1 χ^2= 1.837, p-value= 0.175

Table 5. 10 Regression weights for Employee Involvement (EI)

			Estimate (Unstandardized)	Estimate (Standardized)	Standard Error (S.E.)	Critical Ratio (C.R.)	P
EI1	<---	EI	0.738	0.668	0.092	7.987	***
EI2	<---	EI	0.527	0.469	0.103	5.127	***
EI3	<---	EI	0.612	0.514	0.117	5.249	***
EI4	<---	EI	1.000	0.860			

***P≤0.001

5.6.1.1.3 Measurement model for Supplier Involvement

The construct of Supplier Involvement (SI) contains four items (observed variables) names SI1. SI2, SI3 and SI4. The measurement model is found statistically insignificant as shown in Figure 5.3 and Table 5.11 & 5.12. The chi square (χ_2) value of model is 6.833 with a p-value 0.009 and degree of freedom (df) is 1, which could not indicate the good fit of the data. The other model indices are (χ_2)/df = 0.6.833, GFI =0.792, AGFI = 0.619, RMR = 0.225, NFI = 0.729, CFI = 0.681 and RMSEA = 0.218 shows the unacceptable model fit. The factor loading of each variable is above 0.53 (standardize). As the model fit indices for the construct supplier involvement are unacceptable, this construct cannot be used for further analysis.

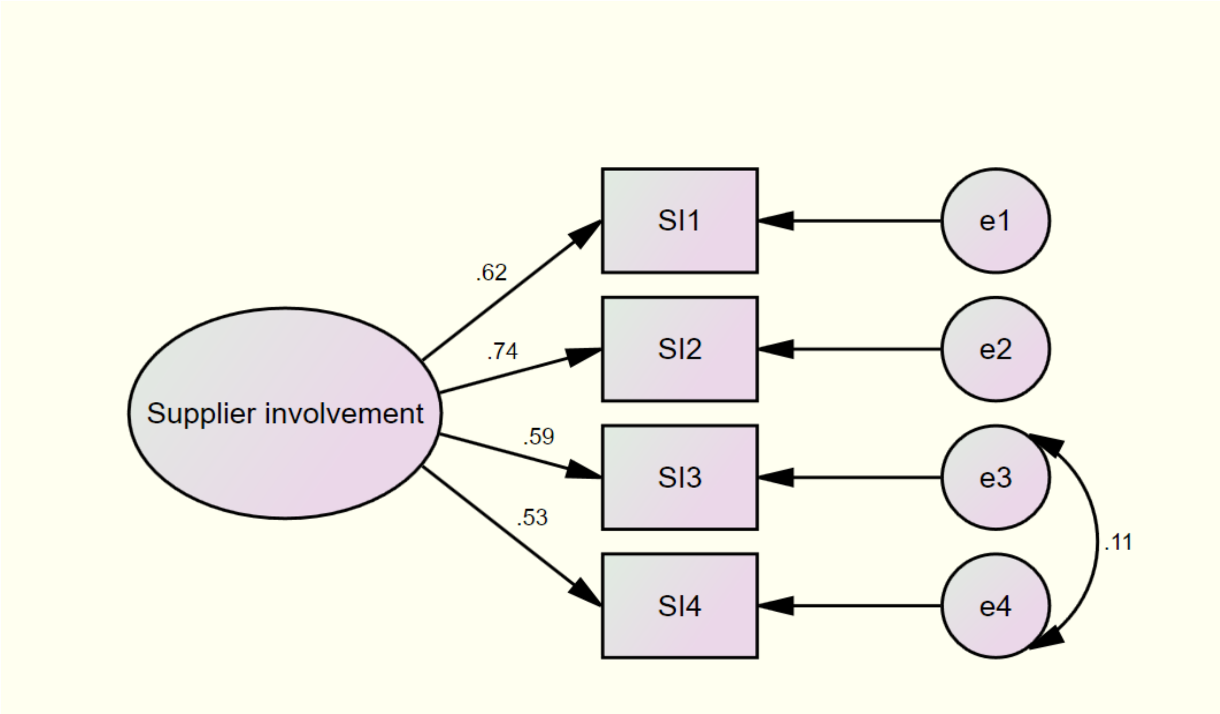

Figure 5. 3 Measurement model for Supplier Involvement (SI)

Table 5. 11 Model fit indices for Supplier Involvement (SI)

Model fit indices	Value of the model
(χ^2)/df	6.833
GFI	0.792
AGFI	0.619
RMR	0.225
NFI	0.729
CFI	0.681
RMSEA	0.218
df= 1, χ^2= 6.833 p-value= 0.009	

Table 5. 12 Regression weights for Supplier Involvement (SI)

			Estimate (Unstandardized)	Estimate (Standardized)	Standard Error (S.E.)	Critical Ratio (C.R.)	P
SI1	<---	SI	0.846	0.622	0.095	8.866	***
SI2	<---	SI	1.000	0.737			
SI3	<---	SI	0.824	0.519	0.101	8.144	***
SI4	<---	SI	0.752	0.534	0.099	7.561	***

***P≤0.001

5.6.1.1.4 Measurement model for Pull system

The construct of Pull System (PS) contains four items (observed variables) names PS1, PS2, PS3 and PS4. The model was found statistically significant as shown in Figure 5.4 and Table 5.13 & 5.14.

The chi square ($\chi 2$) value of model is 0.242 with a p-value 0.886 and degree of freedom (df) is 2 which indicates the best fit of the data. The other model indices are ($\chi 2$)/df = 0.121, GFI = 1.000, AGFI = 0.998, RMR = 0.003, NFI = 0.999, CFI = 1.000 and RMSEA = 0.000 shows the perfect acceptable model fit for further analysis. The factor loading of each variable is above 0.507 (standardize) which support the construct validity of construct PS.

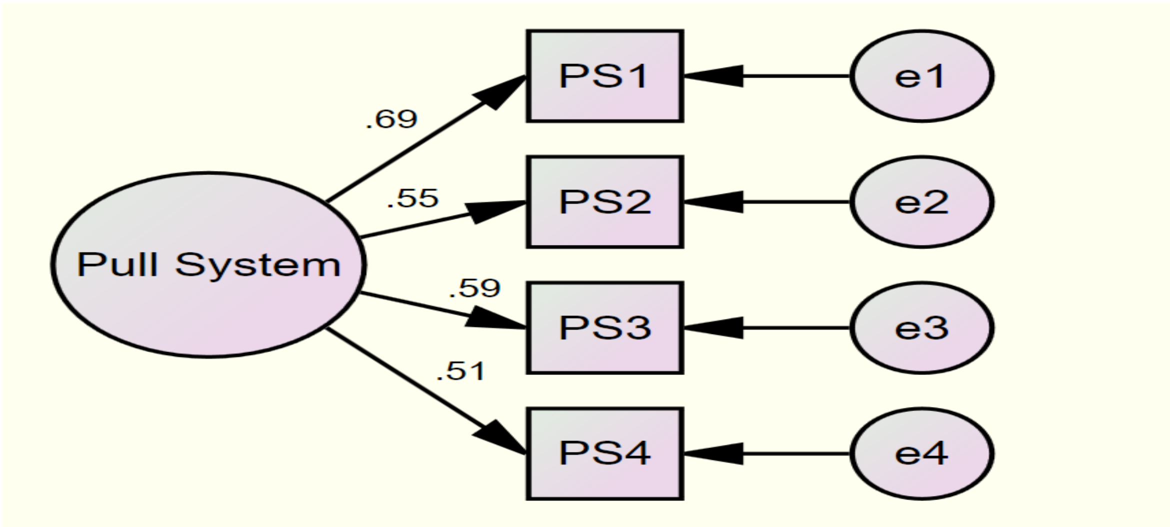

Figure 5. 4 Measurement model for Pull System (PS)

Table 5. 13 Model fit indices for Pull System (PS)

Model fit indices	Value of the model
(χ^2)/df	0.121
GFI	1.000
AGFI	0.998
RMR	0.003
NFI	0.999
CFI	1.000
RMSEA	0.000

df= 2, χ^2= 0.242 p-value= 0.886

Table 5. 14 Regression weights for Pull System (PS)

			Estimate (Unstandardized)	Estimate (Standardized)	Standard Error (S.E.)	Critical Ratio (C.R.)	P
PS1	<---	PS	0.937	0.694	0.123	7.636	***
PS2	<---	PS	0.763	0.553	0.106	7.218	***
PS3	<---	PS	1.000	0.593			
PS4	<---	PS	0.731	0.507	0.107	6.852	***

***P≤0.001

5.6.1.1.5 Measurement model for 5S

The construct of 5S contains five items (observed variables) names @5S1, @5S2, @5S3, @5S4 and @5S5. The measurement model is found statistically significant as shown in Figure 5.5 and Table 5.15 & 5.16. The chi square (χ_2) value of model is 5.824 with a p-value 0.121 and degree of freedom (df) is 3, which could indicate the best fit of the data. The other model indices are (χ_2)/df = 1.941, GFI =0.994, AGFI = 0.970, RMR = 0.015, NFI = 0.987, CFI = 0.994 and RMSEA = 0.050 shows the perfect acceptable model fit for further analysis. The factor loading of each variable is above 0.266 (standardize) which support the construct validity of construct 5S.

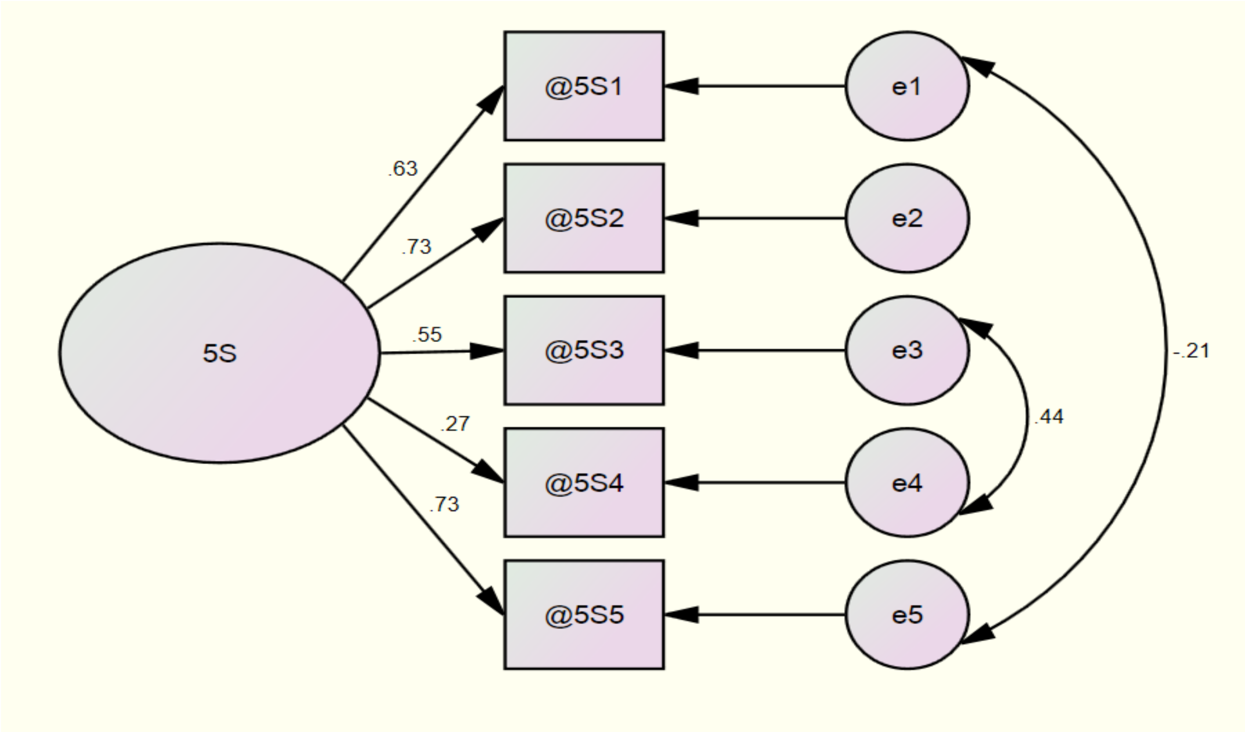

Figure 5. 5 Measurement model for 5S

Table 5. 15 Model fit indices for 5S

Model fit indices	Value of the model
(χ^2)/df	1.941
GFI	0.994
AGFI	0.970
RMR	0.015
NFI	0.987
CFI	0.994
RMSEA	0.050
df= 3, χ^2= 5.824, p-value= 0.121	

Table 5. 16 Regression weights for 5S

			Estimate (Unstandardized)	Estimate (Standardized)	Standard Error (S.E.)	Critical Ratio (C.R.)	P
@5S1	<---	5S	0.875	0.632	0.097	9.003	***
@5S 2	<---	5S	0.915	0.734	0.105	8.701	***
@5S 3	<---	5S	0.827	0.550	0.102	8.078	***
@5S 4	<---	5S	0.513	0.266	0.117	4.383	***
@5S5	<---	5S	1.000	0.727			

***P≤0.001

5.6.1.1.6 Measurement model for Total Productive Maintenance (TPM)

The construct of Total Productive Maintenance (TPM) contains four items (observed variables) names TPM1, TPM2, TPM3 and TPM4. The model was found statistically significant as shown in Figure 5.5 and Table 5.17 & 5.18.

The chi square ($\chi2$) value of model is 0.391 with a p-value 0.532 and degree of freedom (df) is 1 which indicates the best fit of the data. The other model indices are ($\chi2$)/df = 0.391, GFI = 0.999, AGFI = 0.995, RMR = 0.002, NFI = 0.999, CFI = 1.000 and RMSEA = 0.000 shows the perfect acceptable model fit for further analysis. The factor loading of each variable is above 0.597 (standardize) which support the construct validity of construct TPM.

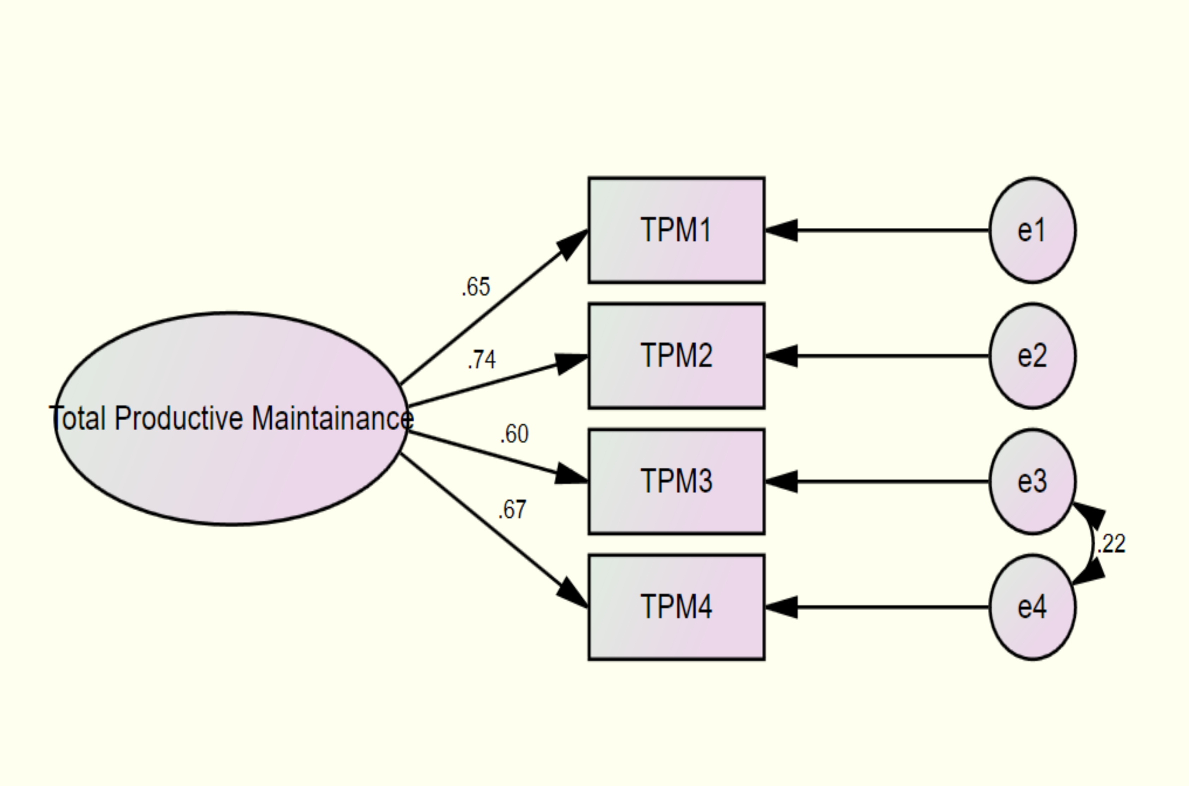

Figure 5. 6 Measurement model for Total Productive Maintenance (TPM)

Table 5. 17 Model fit indices for Total Productive Maintenance (TPM)

Model fit indices	Value of the model
(χ^2)/df	0.391
GFI	0.999
AGFI	0.995
RMR	0.002
NFI	0.999
CFI	1.000
RMSEA	0.000
df= 1,χ^2= 0.391, P-value= 0.532	

Table 5. 18 Regression weights for Total Productive Maintenance (TPM)

			Estimate (Unstandardized)	Estimate (Standardized)	Standard Error (S.E.)	Critical Ratio (C.R.)	P
TPM1	<---	TPM	0.798	0.649	0.083	9.615	***
TPM 2	<---	TPM	1.000	0.741			
TPM 3	<---	TPM	0.736	0.597	0.088	8.368	***
TPM 4	<---	TPM	0.939	0.673	0.102	9.167	***

***P≤0.001

5.6.1.1.7 Measurement model for Statistical Process Control (SPC)

The construct of Statistical Process Control (SPC) contains four items (observed variables) names SPC1, SPC2, SPC3 and SPC4. The measurement model is found statistically significant as shown in Figure 5.7 and Table 5.19 & 5.20. The chi square ($\chi2$) value of model is 0.824 with a p-value 0.662 and degree of freedom (df) is 2, which could indicate the best fit of the data. The other model indices are ($\chi2$)/df = 0.412, GFI =0.999, AGFI = 0.995, RMR = 0.005, NFI = 0.997, CFI = 1.000 and RMSEA = 0.000 shows the perfect acceptable model fit for further analysis. The factor loading of each variable is above 0.469 (standardize) which support the construct validity of construct SPC.

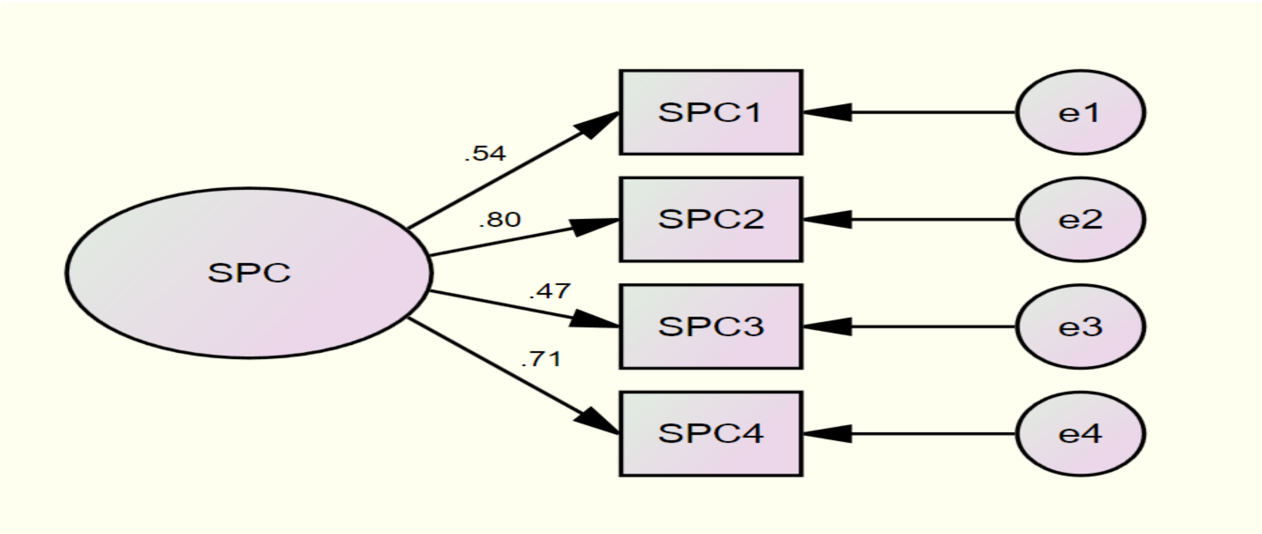

Figure 5. 7 Measurement model for Statistical Process Control (SPC)

Table 5. 19 Model fit indices for Statistical Process Control (SPC)

Model fit indices	Value of the model
(χ^2)/df	0.412
GFI	0.999
AGFI	0.995
RMR	0.005
NFI	0.997
CFI	1.000
RMSEA	0.000
df= 2, χ^2= 0.824, P-value= 0.662	

Table 5. 20 Regression weights for Total Productive Maintenance (TPM)

			Estimate (Unstandardized)	Estimate (Standardized)	Standard Error (S.E.)	Critical Ratio (C.R.)	P
SPC1	<---	SPC	0.722	0.542	0.083	8.737	***
SPC 2	<---	SPC	1.000	0.801			
SPC 3	<---	SPC	0.627	0.469	0.081	7.720	***
SPC 4	<---	SPC	0.982	0.710	0.097	10.113	***

***P≤0.001

5.6.1.1.8 Measurement model for Single Minute Exchange of Dies (SMED)

The construct of Single Minute Exchange of Dies (SMED) contains five items (observed variables) names SMED 1, SMED 2, SMED 3, SMED4 and SMED5. The model was found statistically significant as shown in Figure 5.8 and Table 5.21 & 5.22.

The chi square (χ2) value of model is 7.363 with a p-value 0.118 and degree of freedom (df) is 4 which indicates the best fit of the data. The other model indices are (χ2)/df = 1.841, GFI = 0.993, AGFI = 0.972, RMR = 0.011, NFI = 0.985, CFI = 0.993 and RMSEA = 0.047 shows the perfect acceptable model fit for further analysis. The factor loading of each variable is above 0.565 (standardize) which support the construct validity of construct SMED.

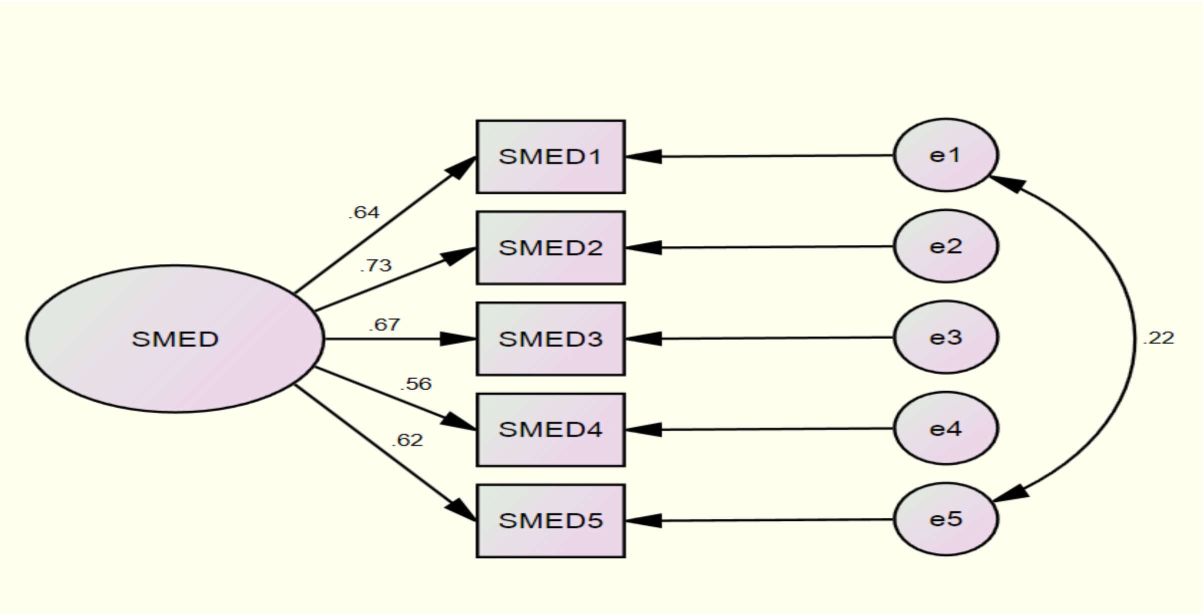

Figure 5. 8 Measurement model for Single Minute Exchange of Dies (SMED)

Table 5. 21 Model fit indices for Single Minute Exchange of Dies (SMED)

Model fit indices	Value of the model
(χ^2)/df	1.841
GFI	0.993
AGFI	0.972
RMR	0.011
NFI	0.985
CFI	0.993
RMSEA	0.047
df= 4, χ^2= 7.363, P-value= 0.118	

Table 5. 22 Regression weights for Single Minute Exchange of Dies (SMED)

			Estimate (Unstandardized)	Estimate (Standardized)	Standard Error (S.E.)	Critical Ratio (C.R.)	P
SMED1	<---	SMED	0.810	0.640	0.082	9.892	***
SMED 2	<---	SMED	1.000	0.734			
SMED 3	<---	SMED	0.722	0.670	0.068	10.559	***
SMED 4	<---	SMED	0.853	0.565	0.092	9.227	**
SMED5	<---	SMED	0.996	0.618	0.104	9.579	***

***P≤0.001

5.6.1.1.9 Measurement model for Visual Management (VM)

The construct of Visual Management (VM) contains three items (observed variables) names VM1, VM2 and VM3. The measurement model is found statistically insignificant as shown in Figure 5.9 and Table 5.23 & 5.24. The chi square ($\chi 2$) value of model is 19.321 with a p-value 0.000 and degree of freedom (df) is 1, which could not indicate the good fit of the data. The other model indices are ($\chi 2$)/df = 19.321, GFI =0.684, AGFI = 0.715, RMR = 0.311, NFI = 0.694, CFI = 0.743 and RMSEA = 0.294 shows the unacceptable model fit. The factor loading of each variable is above 0.326 (standardize). As the model fit indices for the construct visual management are unacceptable, this construct cannot be used for further analysis.

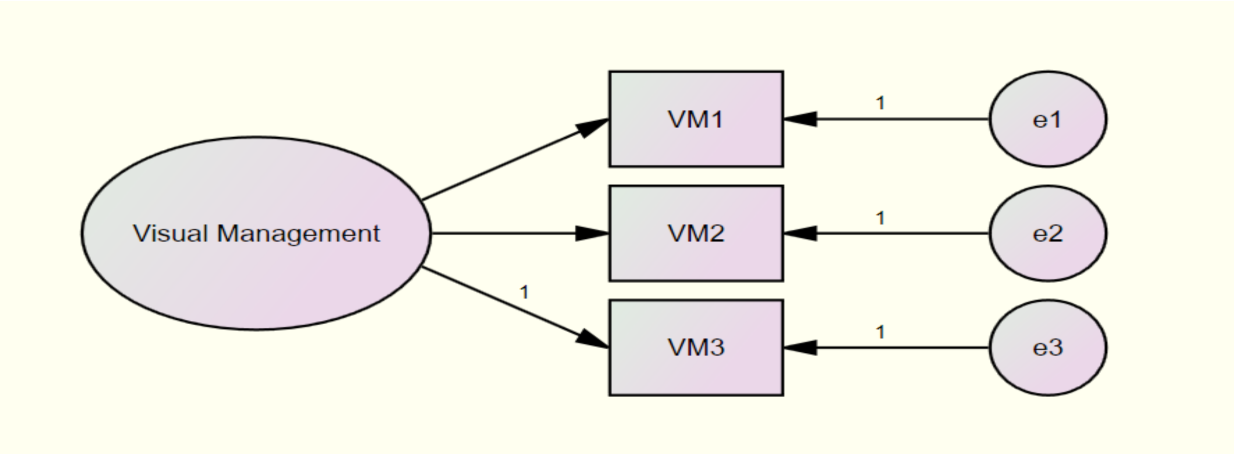

Figure 5. 9 Measurement model for Visual Management (VM)

Table 5. 23 Model fit indices for Visual Management (VM)

Model fit indices	Value of the model
(χ^2)/df	19.321
GFI	0.684
AGFI	0.715
RMR	0.311
NFI	0.694
CFI	0.743
RMSEA	0.294
df= 1, χ^2= 19.321, P-value= 0.000	

Table 5. 24 Regression weights for Visual Management (VM)

			Estimate (Unstandardized)	Estimate (Standardized)	Standard Error (S.E.)	Critical Ratio (C.R.)	P
VM1	<---	VM	0.810	0.365	0.236	3.194	
VM 2	<---	VM	0.745	0.325	0.219	2.569	
VM 3	<---	VM	1.000	0.436			

***P≤0.001

5.6.1.1.10 Measurement model for Production Levelling (PL)

The construct of Production Levelling (PL) contains five items (observed variables) names PL1, PL2, PL3, PL4 and PL5. The model was found statistically significant as shown in Figure 5.10 and Table 5.25 & 5.26.

The chi square (χ2) value of model is 3.912 with a p-value 0.271 and degree of freedom (df) is 3 which indicates the best fit of the data. The other model indices are (χ2)/df = 1.304, GFI = 0.996, AGFI = 0.980, RMR = 0.008, NFI = 0.993, CFI = 0.998 and RMSEA = 0.028 shows the perfect acceptable model fit for further analysis. The factor loading of each variable is above 0.534 (standardize) which support the construct validity of construct Production levelling.

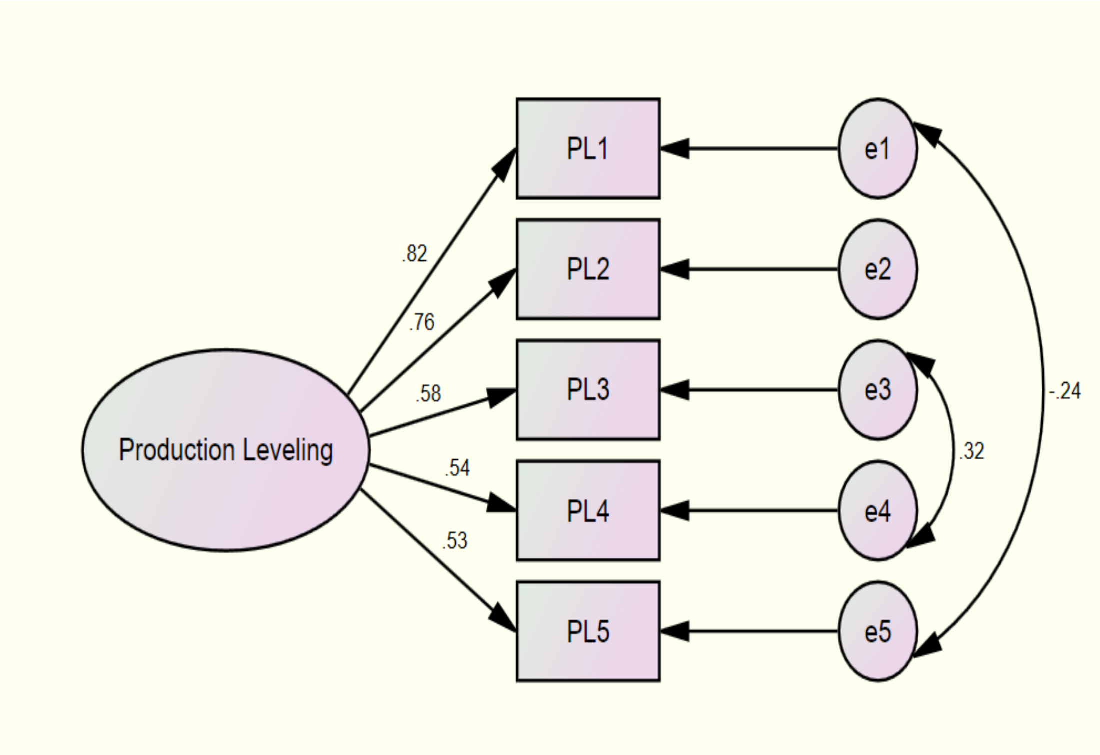

Figure 5. 10 Measurement model for Production Levelling (PL)

Table 5. 25 Model fit indices for Production Levelling (PL)

Model fit indices	Value of the model
(χ^2)/df	1.304
GFI	0.996
AGFI	0.980
RMR	0.008
NFI	0.993
CFI	0.998
RMSEA	0.028
df= 3, χ^2= 3.912, P-value= 0.271	

Table 5. 26 Regression weights for Production Levelling (PL)

			Estimate (Unstandardized)	Estimate (Standardized)	Standard Error (S.E.)	Critical Ratio (C.R.)	P
PL1	<---	PL	0.971	0.818	0.084	11.614	***
PL 2	<---	PL	1.000	0.760			
PL 3	<---	PL	0.727	0.578	0.070	10.330	***
PL 4	<---	PL	0.754	0.545	0.078	9.729	***
PL5	<---	PL	0.737	0.534	0.091	8.099	***

***P≤0.001

5.6.1.1.11 Measurement model for Operational Performance (OP)

The construct of Operational Performance (OP) contains five items (observed variables) names OP1, OP 2, OP 3, OP4 and OP5. The measurement model is found statistically significant as shown in Figure 5.11 and Table 5.27 & 5.28. The chi square ($\chi 2$) value of model is 2.100 with a p-value 0.552 and degree of freedom (df) is 3, which could indicate the best fit of the data. The other model indices are ($\chi 2$)/df = 0.700, GFI =0.998, AGFI = 0.989, RMR = 0.008, NFI = 0.996, CFI = 1.000 and RMSEA = 0.000 shows the perfect acceptable model fit for further analysis. The factor loading of each variable is above 0.637 (standardize) which support the construct validity of construct OP.

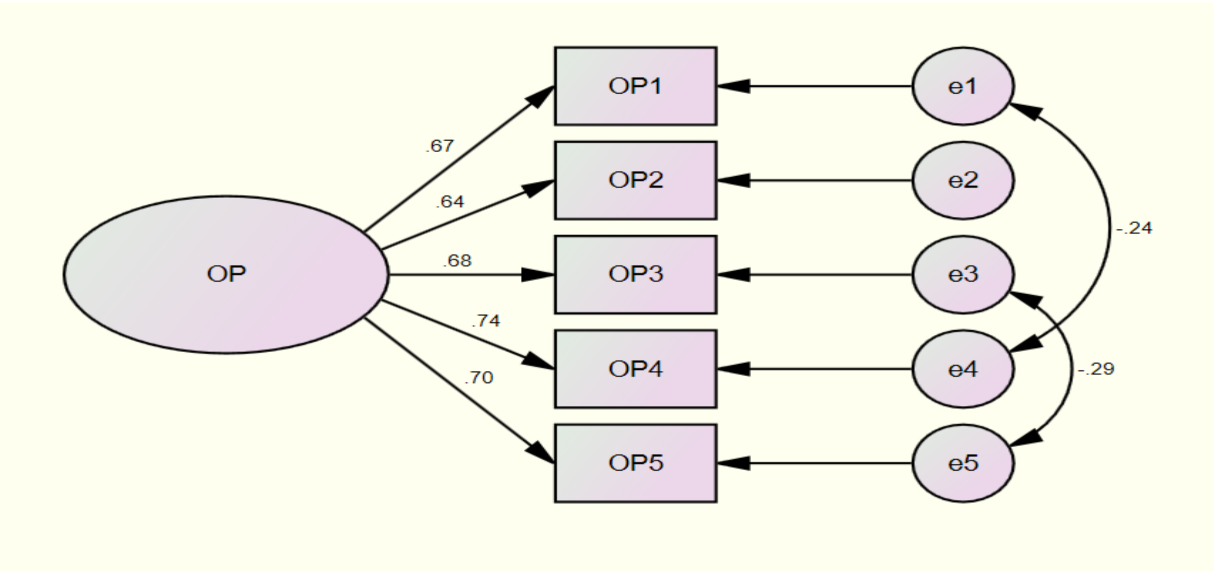

Figure 5. 11 Measurement model for Operational Performance (OP)

Table 5. 27 Model fit indices for Operational Performance (OP)

Model fit indices	Value of the model
(χ2)/df	0.700
GFI	0.998
AGFI	0.989
RMR	0.008
NFI	0.996
CFI	1.000
RMSEA	0.000
df=3, χ^2=2.100, P value=0.552	

Table 5. 28 Regression weights for Operational Performance (OP)

			Estimate (Unstandardized)	Estimate (Standardized)	Standard Error (S.E.)	Critical Ratio (C.R.)	P
OP1	<---	OP	1.000	0.671			
OP2	<---	OP	.770	0.637	.076	10.186	***
OP3	<---	OP	.807	0.679	.083	9.752	***
OP4	<---	OP	.921	0.744	.085	10.779	***
OP5	<---	OP	.973	0.695	.098	9.917	***

***P≤0.001

5.6.1.1.12 Measurement model for Financial Performance (FP)

The construct of Financial Performance (FP) contains four items (observed variables) names FP1, FP2, FP3 and FP5. The model was found statistically significant as shown in Figure 5.12 and Table 5.29 & 5. 30.

The chi square (χ2) value of model is 0.620 with a p-value 0.431 and degree of freedom (df) is 1 which indicates the best fit of the data. The other model indices are (χ2)/df = 0.620, GFI = 0.999, AGFI = 0.992, RMR = 0.004, NFI = 0.998, CFI = 1.000 and RMSEA = 0.000 shows the perfect acceptable model fit for further analysis. The factor loading of each variable is above 0.472 (standardize) which support the construct validity of construct Production levelling.

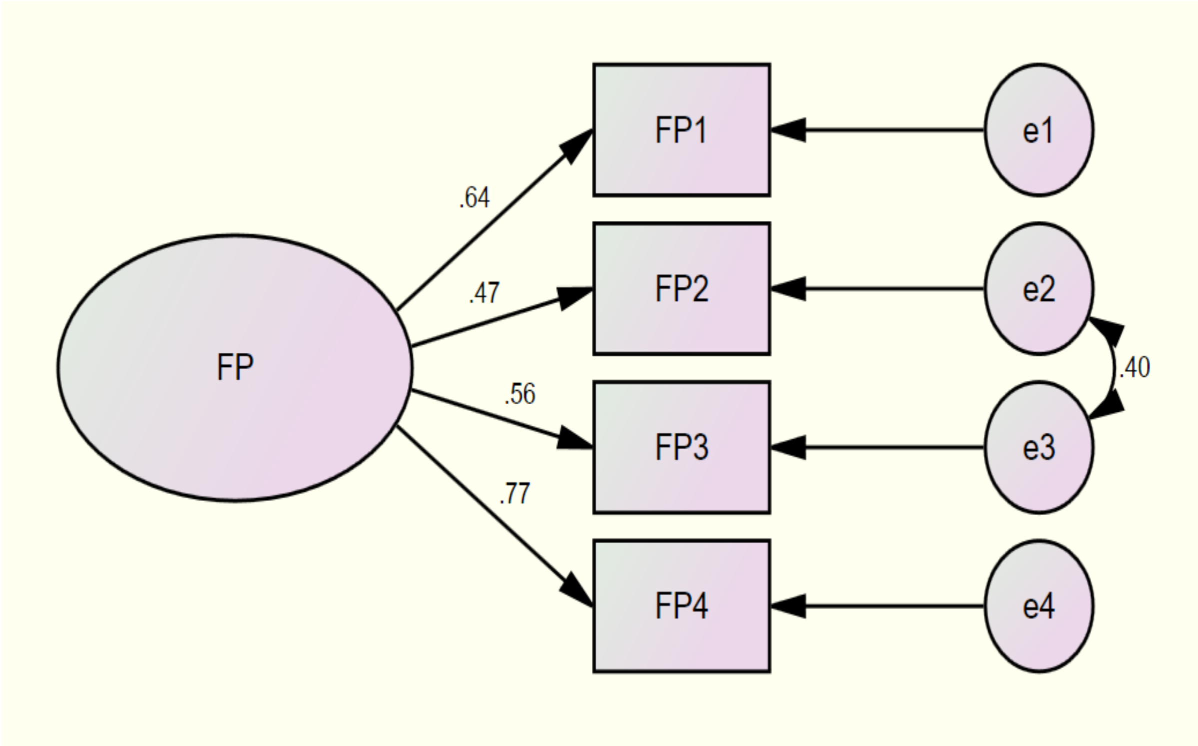

Figure 5. 12 Measurement model for Financial Performance (FP)

Table 5. 29 Model fit indices for Financial Performance (FP)

Model fit indices	Value of the model
(χ^2)/df	0.620
GFI	0.999
AGFI	0.992
RMR	0.004
NFI	0.998
CFI	1.000
RMSEA	0.000
df=1, χ^2=0.620, P value=0.431	

Table 5. 30 Regression weights for Financial Performance (FP)

			Estimate (Unstandardized)	Estimate (Standardized)	Standard Error (S.E.)	Critical Ratio (C.R.)	P
FP1	<---	FP	.708	0.640	.089	7.978	***
FP2	<---	FP	.545	0.472	.082	6.679	***
FP3	<---	FP	.771	0.563	.101	7.606	***
FP4	<---	FP	1.000	0.773			

***P≤0.001

One factor congeneric model for all the research constructs has been developed. From the analysis, it found that the model fit indices for all research constructs are statistically significant and these constructs are used for further analysis.

5.6.1.2 Multifactor congeneric model

The multi factor congeneric models are further developed with the prime objective to investigate the Discriminant and construct validity by confirmatory factor analysis. This technique employs the test of goodness of fit to the data to examine the measurement and structural model. The investigation of one factor congeneric model, the second step of multifactor congeneric are examined. There is total ten construct, on the basis of research gaps identified from the literature, two frameworks are proposed: (i) Analysis of practices of lean thinking in SMEs, (ii) analysis of impact of lean practices on performance measures. For this purpose, two multifactor congeneric models are developed given as:

I. Multifactor congeneric model to analyze of the lean thinking practices in SMEs
II. Multifactor congeneric model to analyze the impact of lean practices on performance measures.

Multiple fit indices are employed in reporting model fit using AMOS 22.0. various indices are considered based on goodness of fit test for predicted vs. observed covariance study like chi square (χ^2) (CMIN), ration of chi square to degree of freedom (χ^2/df) or (CMIN/df), goodness of fit index (GFI), adjusted goodness of fit index (AGFI), normed fit index (NFI), comparative fit index (CFI) and root mean square residual (RMR) for covering the divers statistical aspects. The very common recommendation to report the fit indices proposes the chi square (χ^2) and root mean square error of approximation (RMSEA) tests.

5.6.1.2.1 Multifactor congeneric model to analysis of the lean thinking practices

As discussed in the literature review, the lean thinking includes customer involvement, employee involvement, supplier involvement, Pull system, 5S, Statistical process control, Total productive maintenance, Single minute exchange of dies, Visual management and Production levelling. Congeneric model for construct supplier involvement and visual management are not found statistically significant, hence these constructs are not included in further analysis.

To investigate the behaviour of rest eight practices, study was performed using first order measurement model and second order measurement model. In the first order model CI, EI, PS, 5S, SPC, TPM, SMED and PL are correlated to each other as measurement dimensions for Lean Thinking (Lean). While, second order model will assess contribution level of each practice to lean.

5.6.1.2.1.1 First order measurement model

Based on the analysis done using AMOS 22.0, the first order model for sustainable manufacturing is developed by first order confirmatory factor analysis as depict in Figure. 5.13. The first order model suggests that there are eight practices (constructs) (i.e. CI, EI, PS, 5S, SPC, TPM, SMED and PL) in the model. The practices are independent in their prediction of sustainable manufacturing. The construct such as CI, EI, PS, 5S, SPC, TPM, SMED and PL are measured by four, four, four, five, four, four, five, and five items respectively as shown in Figure 5.13. The first order model for Lean thinking passed all the required tests.

In this study, to test the reliability and validity of the reflective constructs, estimates (standardized), squared multiple correlations (R^2), Average Variance Extracted (AVE) and Composite Reliability (CR) are used. Table 5.29 shows the values of these measures for the research model.

Uni-dimensionality measures the extent to which the items in a scale measure the same construct (Venkatraman, 1989). Squared multiple correlations (R^2) indicate the percentage of variance in an indicator explained by a certain construct. As per the Table 5.31, the relevant squared multiple correlations (R^2) are significant, ranging from 0.563 to 0.782. This confirms that a significant degree of calculated variable's variance is provided by its latent construct. Hence, all of the eight constructs have good fit and thus are unidimensional.

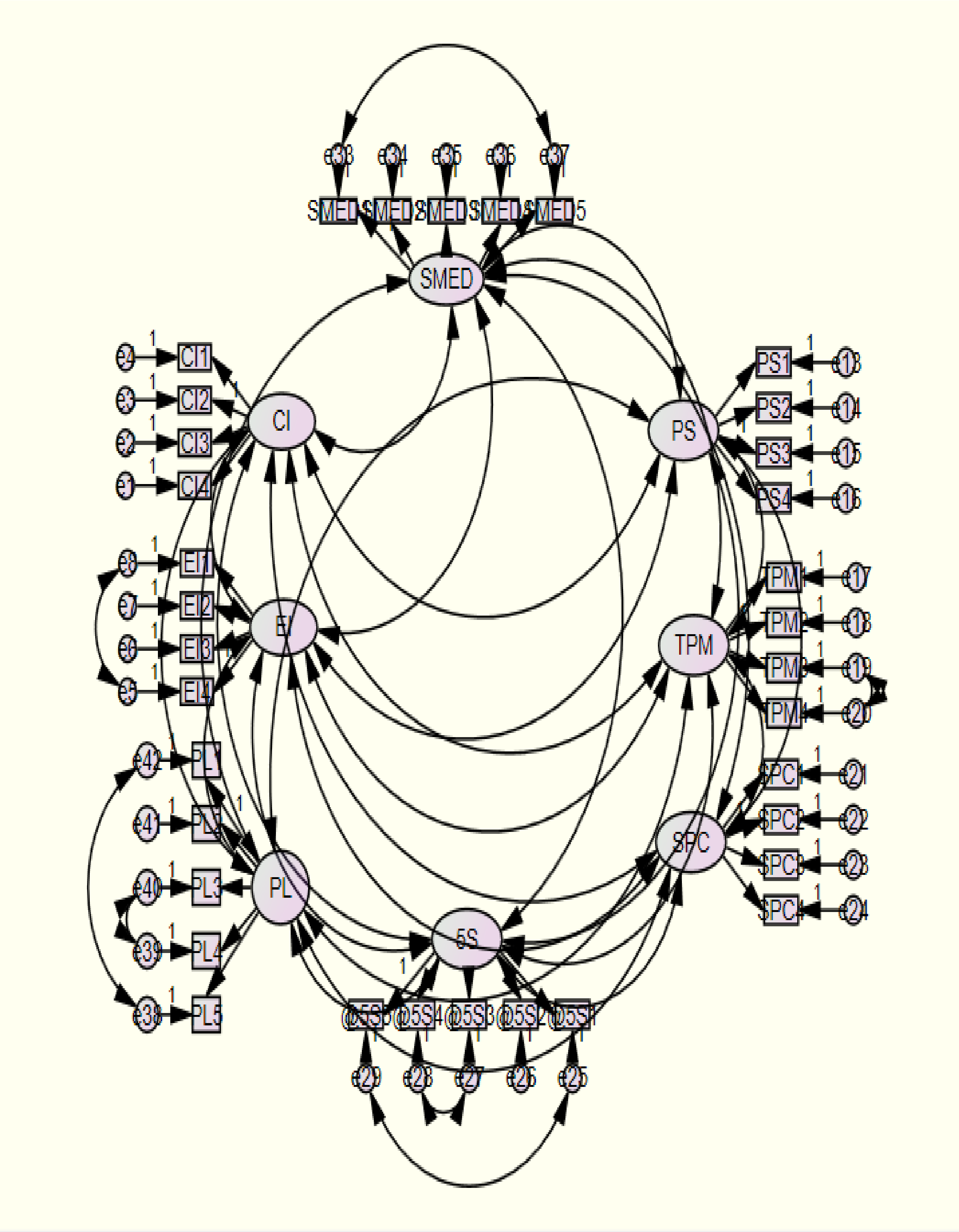

Figure 5. 13 First order measurement model

Table 5. 31 CFA results for measurement model

First order latent variable	Manifest variable	Manifest Variable loading	P value	R^2	AVE	CR	α	CO	Construct loading	P value
CI	CI1	0.713	0.000	0.778	0.529	0.818	0.723	0.529	0.892	0.000
	CI2	0.721	0.000							
	CI3	0.740	0.002							
	CI4	0.736	0.000							
EI	EI1	0.715	0.001	0.745	0.577	0.844	0.782	0.577	0.862	0.000
	EI2	0.736	0.000							
	EI3	0.743	0.000							
	EI4	0.839	0.002							
PS	PS1	0.734	0.000	0.683	0.602	0.857	0.802	0.602	0.812	0.001
	PS2	0.794	0.000							
	PS3	0.829	0.001							
	PS4	0.743	0.004							
5S	5S1	0.749	0.004	0.582	0.555	0.861	0.799	0.555	0.753	0.008
	5S2	0.785	0.002							
	5S3	0.726	0.002							
	5S4	0.712	0.001							
	5S5	0.753	0.000							
TPM	TPM1	0.723	0.000	0.723	0.583	0.848	0.729	0.583	0.849	0.000
	TPM2	0.742	0.000							
	TPM3	0.762	0.000							
	TPM4	0.824	0.000							
SPC	SPC1	0.705	0.000	0.782	0.554	0.832	0.699	0.554	0.904	0.002
	SPC2	0.725	0.000							
	SPC3	0.797	0.001							
	SPC4	0.748	0.001							
SMED	SMED1	0.757	0.000	0.563	0.587	0.876	0.836	0.587	0.746	0.001
	SMED2	0.760	0.000							
	SMED3	0.780	0.000							
	SMED4	0.721	0.000							
	SMED5	0.812	0.000							
PL	PL1	0.724	0.000	0.642	0.528	0.870	0.733	0.528	0.780	0.000
	PL2	0.720	0.001							
	PL3	0.712	0.002							
	PL4	0.780	0.001							
	PL5	0.723	0.001							

Where: AVE: average variance extracted; CR: composite reliability; α: cronbach's alpha; CO: communality;

To assess the quality of the measurement model, convergent validity, composite reliability, communality, and discriminant validity were measured. The convergent validity is the level to which a latent construct describes the variance of its measurements. The average variance extracted (AVE) is a dimension of convergent validity. Composite reliability is a measure of internal consistency assessed by Cronbach's alpha. Communality explains the degree to which the variation in an item is explained by the construct and is referred to as variance extracted from the item. The discriminant validity (DV) is the degree to which a factor is really different from the other factors and also the degree by which an item is related to a construct (Hair et al. 2013). The reference values for these statistical quality measures are presented in Table 5.32.

Table 5. 32 Statistical quality measures

Measure	Value	Reference
Number of manifest variables per latent variable	≥3.0	Flynn et al. 1990;
Cronbach's alpha of latent variable	≥0.7	Malhotra and Grover 1998; Shah and Goldstein 2006; Hair et al. 2013
Average variance extracted of latent variable	≥0.5	
Composite reliability of latent variable	≥0.7	
Communality of latent variable	≥0.5	
Loading of latent variable	≥0.7	
Loading of manifest variable	≥0.7	

The values of the statistical quality measures are presented in Table 5.29. Based on reference values and actual values of the measures for the all eight constructs were under an acceptable range which was considered for the further analysis.

To evaluate fitness of the model, fit indices viz. χ^2 /df (df=degree of freedom), normal fit index (NFI), comparative fit index (CFI), goodness of fit (GFI), adjusted goodness of fit (AGFI), root mean square residual (RMR), and root mean square of error approximation (RMSR) were used. A good fit model should have the values of GFI, AGFI, NFI, and CFI close to 1 or greater than 0.9 and the values of RMSEA $\leq$ 0.5 (Byrne 2013; Kline 2015). According to Schermelleh-Engel *et al.* (2003), a value of RMR between 0.05 and 0.10 is considered good.

The chi square ($\chi2$) value of model is 1409.278 and degree of freedom (df) is 525, which could indicate the best fit of the data. The other model indices are ($\chi2$)/df = 2.684, GFI =0.816, AGFI = 0.780, RMR = 0.051, NFI = 0.734, CFI = 0.892 and RMSEA = 0.066 shows the perfect acceptable model fit for further analysis.

5.6.1.2.1.2 Second order measurement model

In order to assess the lean tools and operational performance relationship it was imperative to create a second-order structural model. In the structural model, a second-order latent construct, 'Lean', was created by means of a reflective construct model. The primary condition for this type of modeling is that all first-order latent variables should have a significant correlation. Table 5.33 presents the correlations between lean practices (first-order latent constructs). It can be seen that 100 percent and 93 percent correlations are significant at the level of 0.05 and 0.01 respectively. Thus the analysis suggests the existence of a second-order latent construct.

Table 5. 33 Pearson correlations between first-order variables (lean practices)

Constructs	CI	EI	PS	5S	TPM	SPC	SMED	PL
CI	1.00							
EI	0.47**	1.00						
PS	0.19*	0.18*	1.00					
5S	0.34**	0.33**	0.29**	1.00				
TPM	0.52**	0.36**	0.32**	0.35**	1.00			
SPC	0.50**	0.39**	0.25**	0.36**	0.58**	1.00		
SMED	0.32**	0.21**	0.43**	0.38**	0.21**	0.24**	1.00	
PL	0.51**	0.24**	0.28**	0.36**	0.56**	0.59**	0.25**	1.00

** Correlation is significant at the level of 0.01(2-tailed) 26 out of 28

* Correlation is significant at the level of 0.05(2-tailed) 28 out of 28

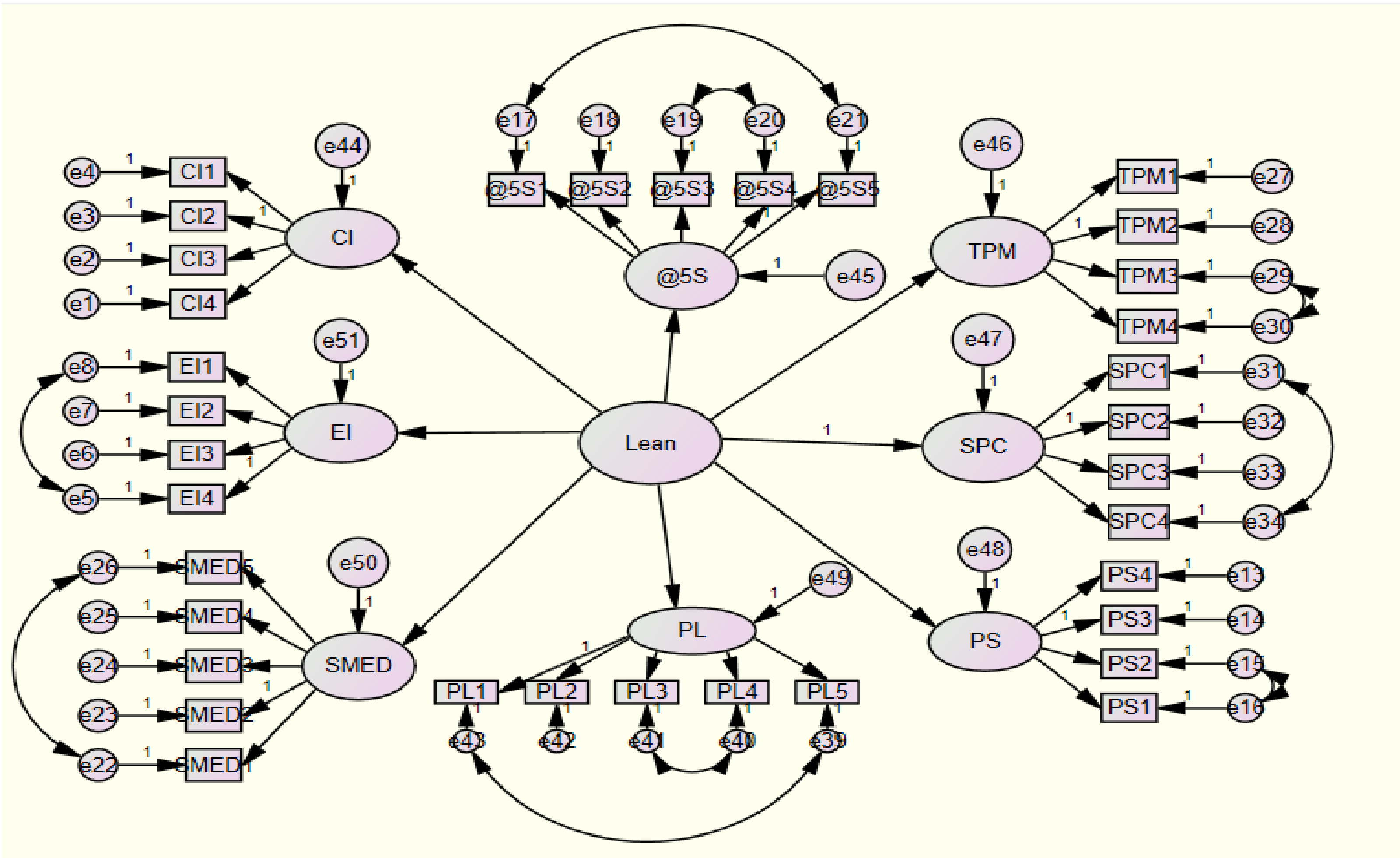

Figure 5. 14 Second order measurement model

Before testing the research hypotheses through structural model, a confirmatory factor analysis was run as shown in Figure 5.14 to identify a statistically suitable final model. All constructs that are kept in the model fulfil the necessary requirements and are therefore considered meaningful. The results of confirmatory factor analysis for the second order measurement model for main construct (Lean) and sub constructs/dimensions/practices (CI, EI, PS, 5S, SPC, TPM, SMED and PL) were computed.

Second order model for sustainable manufacturing was developed by second order confirmatory factor analysis by using AMOS 22.0 software package. The path loading from the second order constructs (Lean) to all the eight constructs (practices) was significant with $p<0.001$.

The results of second order model for Lean construct qualified all the goodness of fit parameters. The chi square ($\chi 2$) value of model is 1498.000 with degree of freedom (df) is 543, ($\chi 2$)/df = 2.759, GFI = 0.800, AGFI = 0.768, RMR = .053, NFI = 0.758, CFI = 0.863 and RMSEA = 0.068. The results show that the lean construct was considered as second order construct and it was also supported in the previous studies.

5.6.1.2.2 Multifactor congeneric model to analyze the impact of lean practices on performance measures

In the last section, a second order construct 'lean' which represents the eights practices was developed and this second order construct was found to be statistically fit for further analysis. In order to examine the relationship between lean implementation and operational performance, a measurement model for all constructs (eight practices, 'Lean' and Operational performance) has been developed with various statistical procedures in this section.

In addition, structural model has been developed to test the relationship between Lean thinking and lean practices (H5, H6, H8, H9, H10, H11, H12, H14) and lean thinking and operational performance (H15). In order to develop multifactor model and test the hypothesis proposed, a structural model using AMOS 22.0 software package is created with the maximum likelihood method as shown in Figure 5.15.

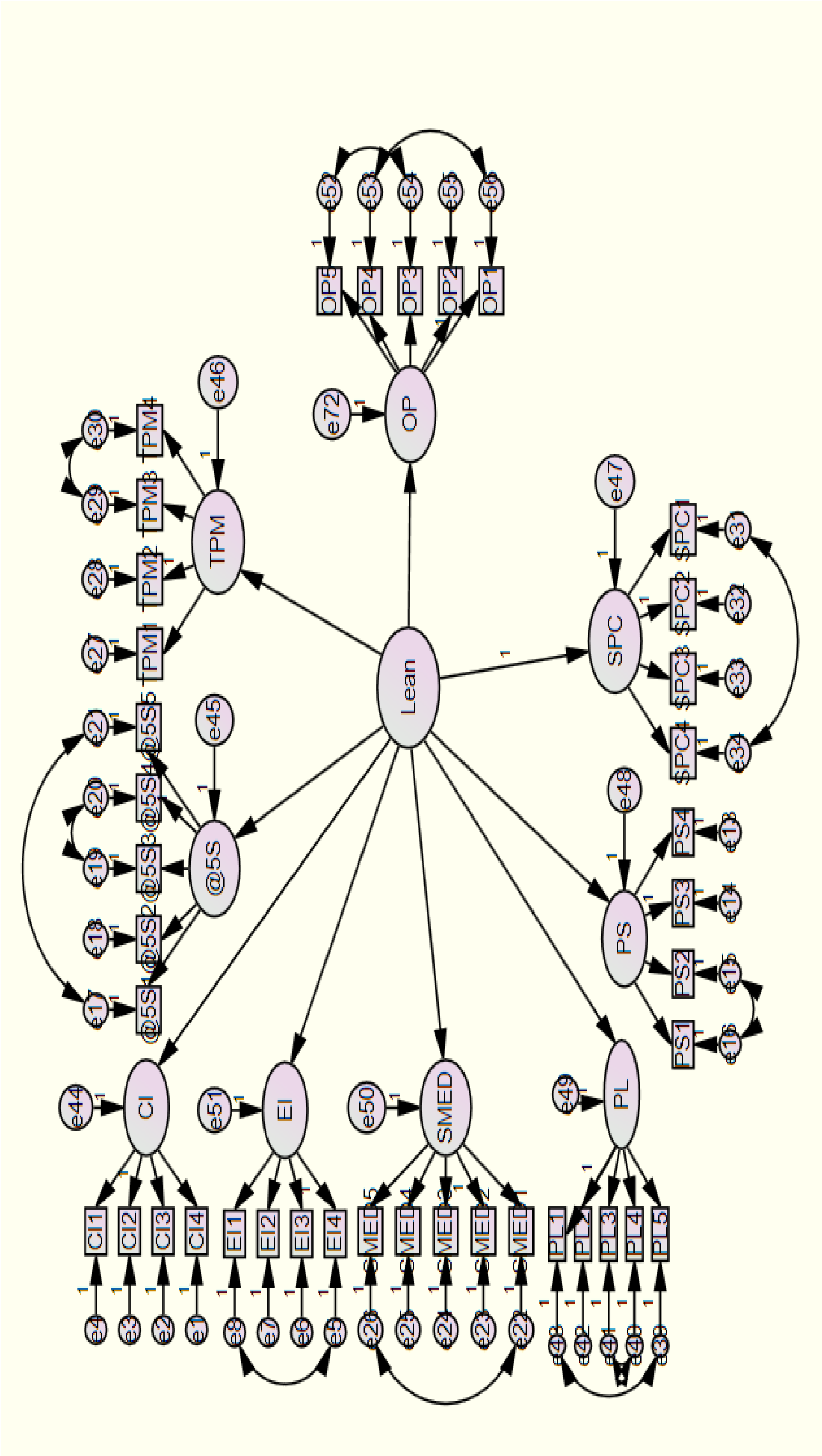

Figure 5. 15 Multifactor Structural equation model for OP

Quality measures for the model are presented in Table 5.34. The model was found to be appropriate for all the statistical quality measures. Goodness of fit indices for final model were χ^2 /df=2.572, GFI = 0.886, AGFI = 0.856, RMR = 0.051, NFI = 0.772, CFI = 0.890 and

RMSEA = 0.064. These results validate the proposed model. Loadings for different relationships in the model are shown in Figure 5.16. The relationship between lean thinking and operational performance is positive, and the loading between the lean and OP constructs was 0.890 which is statistically significant ($R^2 = 0.8$; p-value = 0.001).

Table 5. 34 Testing the quality of the structural model

Constructs	AVE	CR	α	CO
CI	0.529	0.818	0.723	0.529
EI	0.577	0.844	0.782	0.577
PS	0.602	0.857	0.802	0.602
5S	0.555	0.861	0.799	0.555
TPM	0.583	0.848	0.729	0.583
SPC	0.554	0.832	0.699	0.554
SMED	0.587	0.876	0.836	0.587
PL	0.528	0.870	0.733	0.528
Lean	0.502	0.845	0.835	0.502
OP	0.583	0.873	0.775	0.583
Where: AVE: average variance extracted, CR: composite reliability, α: cronbach's alpha, CO: communality				

5.6.1.2.2.1 Discussion of hypotheses between the Research Constructs

The discussion presented in this section represent a theory driven examination of how the lean practices, lean thinking implementation and operational performance are associated with each other in the Indian SMEs.

The results indicate that the scale items to measure the model's constructs are reliable and valid; and an excellent fit between the theoretical model and the data model. Table 5.33, shows the standardise estimates and result of the hypothesises.

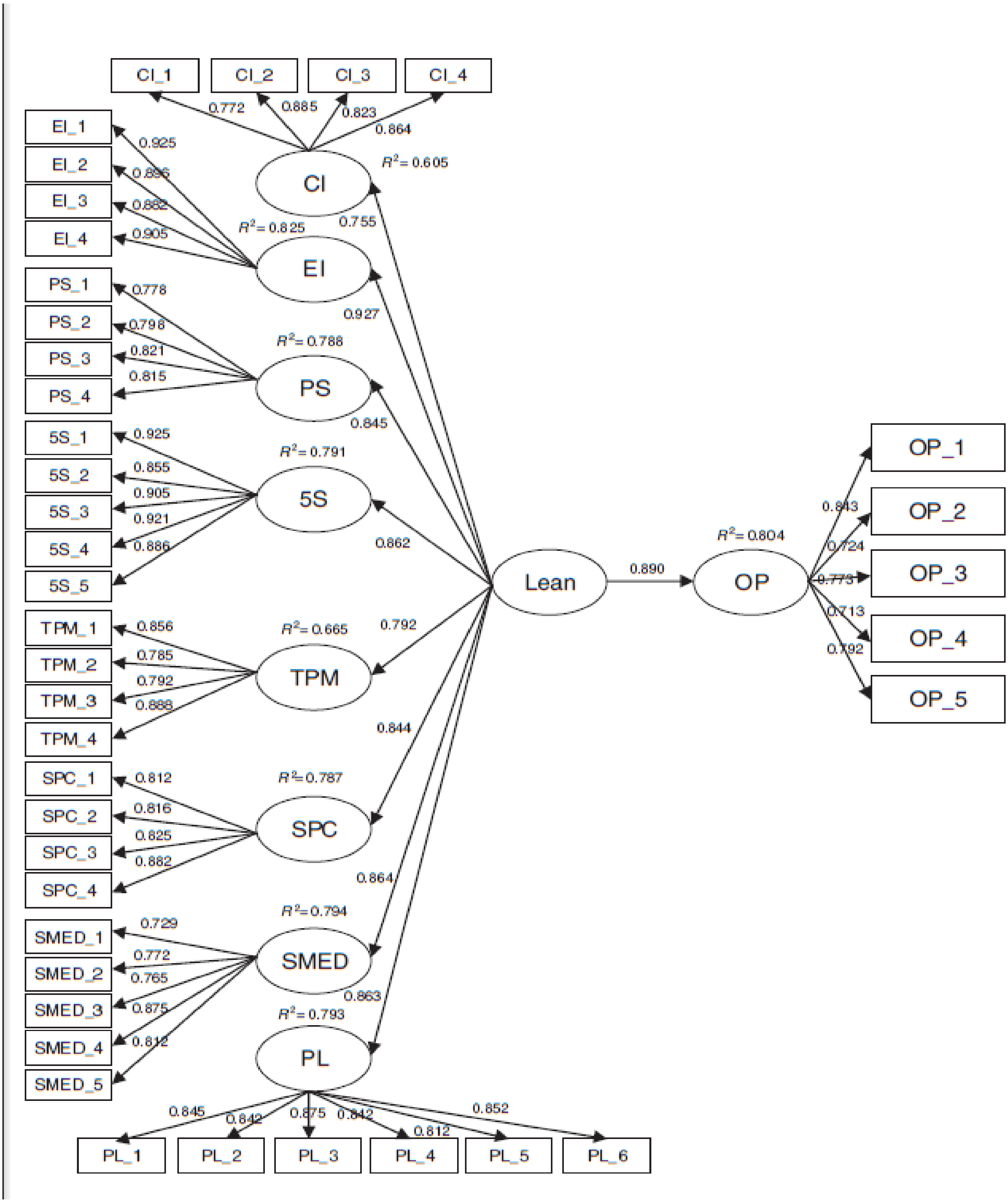

Figure 5. 16 Relationships between practices, lean thinking and operational performance

Table 5. 35 Results of Structural model

Hypotheses				Estimate (Standardized)	Standard Error (S.E.)	Critical Ratio (C.R.)	P	Remarks
H5	CI	<---	Lean	0.755	0.089	8.878	***	Supported
H6	EI	<---	Lean	0.927	0.082	7.639	***	Supported
H8	PS	<---	Lean	0.845	0.101	9.656	***	Supported
H9	5S	<---	Lean	0.862	0.043	10.234	***	Supported
H10	TPM	<---	Lean	0.792	0.042	10.885	***	Supported
H11	SPC	<---	Lean	0.844	0.082	9.832	***	Supported
H12	SMED	<---	Lean	0.864	0.094	9.349	***	Supported
H14	PL	<---	Lean	0.863	0.132	9.532	***	Supported
H15	Lean	<---	OP	0.890	0.106	9.875	***	Supported

***P<0.001

As per the results reported in Table 5.35, the relationships between eight lean practice (CI, EI, PS, 5S, SPC, TPM, SMED and PL) with lean thinking construct is statistically significant. Hence, the hypotheses H5, H6, H8, H9, H10, H11, H12 and H14 is accepted which indicates significant relationship between customer involvement and lean thinking (H5), significant relationship between employee involvement and lean thinking (H6), significant relationship between pull system and lean thinking (H8), significant relationship between 5S and lean thinking (H9), significant relationship between total productive maintenance and lean thinking (H10), significant relationship between statistical process control and lean thinking (H11), significant relationship between single minute exchange of dies and lean thinking (H12), and significant relationship between production levelling and lean thinking (H14).

One of the objectives of the current research was to assess the impact of lean implementation on the operational performance of SMEs. From the results, it was revealed that the implementation of lean practices is positively associated with the operational performance of SMEs. This study supports the common perception of researchers that lean adoption has a positive impact on the operational performance of the organization (Shah and

Ward, 2007; Panwar et al., 2018). Further, it may be concluded that the positive impact of lean on operational performance in SMEs can be observed even when the lean practices are implemented in a partial manner.

5.6.1.2.2.2 Multifactor congeneric model to analyze the impact of lean practices on financial performance

In this research, the methodology suggested by Baron and Kenny (1986) and Fullerton and Wempe (2009) was adopted to test the mediating effect of operational measures in the research model. According to these research, for evaluating the mediating effect of operational performance construct, firstly independent (lean) construct must have significant relationship with outcome construct (Financial performance) in a reduced model in which the mediator construct (operational performance) was removed. Secondly, the mediator construct must be significantly related to the outcome construct and the independent construct. The last condition for mediation was the direct relationship of between the independent construct and outcome construct in the full structural model. If there is absence of this relationship and other conditions are satisfactory, there is full mediation will occur, or on another hand if the relation shows a reduction in significance, partial mediation will occur.

Table 5. 36 Results of the structural model

Relationships	Hypothesis	Standardized coefficient	t-values
Lean → OP	H16	0.485	2.892***
Lean → FP	H17	0.114	0.625
OP → FP	H18	0.527	2.977***
Model fit indices: χ^2 /df=1.423; GFI = 0.882; AGFI = 0.903; RMR = 0.021; NFI = 0.883; CFI = 0.946; RMSEA = 0.032, *p<0.10, **p<0.05, ***p<0.01			

Initially the direct effect of lean on financial performance (H17) was evaluated by eliminating the operational performance construct from the research model. The standard coefficient for the partial model was significant (0.629; p<0.01) and the fit indices were also acceptable. Prior studies also replicate the analogous results. Likewise, to test the direct effect of lean on operational performance (H16), the financial performance construct was eliminated from the research model. For this reduced model, all the fitness indices had acceptable values and the standardize coefficient found significant (0.787; p<0.01).

Table 5. 37 Regression results from mediation effect on economic performance.

Independent variable	Dependent variable	Standardize coefficient	F-statistic	Adjusted R^2	Sobel test statistic
Operational performance	Economic performance	0.423***			
Lean	Economic performance	0.182*			
			9.426***	0.138	3.426***
*p<0.10, **p<0.05, ***p<0.01					

Subsequently, the full structural model was subjected to the goodness of fit tests. All the fitness indices for the structural model found acceptable. Table 5.36 demonstrates the results of the full structural model. The path between operational performance and financial performance was significant; hence the operational performance is positively related to financial performance, supporting the hypothesis (H18). Similarly, the relationship between lean and operational performance also found significant but the relationship between lean construct and financial performance was not significant. These results demonstrate that the operational performance fully mediates the relationship between lean implementation and financial performance (H19). Moreover, the results of Sobel test (1986) demonstrated in Table 5.37, also suggest that operational performance mediates the relationship of financial performance to lean implementation. For the full structural model, the direct effect (0.114), indirect effect (0.231***) and total effect (0.345***) were also support the hypothesis H19 and concluded that the operational performance mediates effect of lean implementation on financial performance.

5.7 Conclusions

Most of the existing studies are mainly concentrating on the large enterprises, but their findings may not be consistent with SMEs due to the characteristical difference between two. As compared to large enterprise, SMEs have limited resources, less expertise, and fewer skills; thus, with these constraints, it is not possible for SMEs to adopt full lean in their organization and in supply chain. Therefore, SMEs especially working in developing economy are implementing lean in a partial manner or with a piecemeal approach.

Prior literature advocates the adoption of lean thinking in an integrated way for achieving the operational and financial benefits. This is true for the large enterprises where the resources and skills are not the constraints, while SMEs adopt the lean in a partial manner or with a piecemeal approach. None of the existing research has empirically tested the impact of this partial adoption of lean in SMEs. This study provides a clear picture of the relationships among partial lean adoption, operational performance and financial performance in the context of SMEs. The evidence from this study suggests that even in a partial manner, lean is capable of improving the operational and financial performance of the organization. The findings also confirm the mediating role of the operational performance in deriving the economic performance associated with lean adoption.

This study confirms the perception that rather than a full lean concept, SMEs are adopting lean in a partial manner, i.e., implementing a limited number of practices (H14); eight (out of ten) lean practices are in the core concept of lean thinking for SMEs. Full implementation of lean requires a lot of investment, whereas generally SMEs do not have sufficient financial support. Additionally, lack of skills and expertise also restricts SMEs to full lean implementation in an integral manner. This finding is consistent with Filho *et al.* (2016) which empirically tested the hypothesis that SMEs are implementing a limited number of lean practices in a fragmented way. Findings of the study also support the argument that when a new sector adopts lean, it will adapt to support the adoption and implementation of the new practices. Hence, the study validates the dynamic nature of lean (Holweg *et al.* 2007).

One of the objectives of the current research was to assess the impact of lean implementation on the operational performance of SMEs. From the results, it is revealed that the application of lean practices is positively associated with the operational performance of SMEs (H16). Hence it can be concluded that even in the partial manner the impact of lean on the operational performance is positive and significant. The results are in line with the prior studies (Filho *et al.* 2016; Panwar *et al.* 2018). This finding reveals that the lean implementation can helps SMEs with inventory reduction, productivity improvement, wastes elimination, and cutting down costs. Apart from that this study also confirms that the adoption of partial lean adoption also has a positive impact on the economic performance. This result is consistent with Fullerton and Wempe (2009) and Hofer *et al.* (2012). The finding further implies that the partial lean adoption in SMEs supports the profitability of the organisation.

A major finding of the study is the mediating role of the operational measures in the relationship between the partial lean adoption and the economic performance. It implies that lean adoption not only improves that operational measures but also positively affects the financial measures. The operational measures like inventory reduction, productivity improvement, wastes elimination, and cutting down costs, directly affect the profitability.

Chapter 6
Case studies

6.1 Introduction

This chapter aims at to get deeper insights of the findings of the survey discussed in previous chapters by employing case study approach. Four case studies were carried out to get a better understanding of lean adoption in Indian SMEs and will help in interpretation of proposition formulated in this study. This will also help to check the validity of survey findings.

Case study method is used in conjunction with survey research to develop explanations for some of the findings on a more comprehensive basis (Eisenhardt, 1989;). Case study approach uses the both qualitative and quantitative methods with an aim to understand the underlying phenomenon completely. According to the Gubrium (1988) case study research is a scientific approach to correct the theoretical concepts with real time events. Yin (2003) identified that case study can be employed to explain a hypothesis.

The cases were selected in such a way as to maximize variation on dimensions that are of potential importance for the degree of lean implementation according to the extant literature. The selected cases were expected to be different with regard to heterogeneity on production dimensions such as raw materials and products, production process; degree of inventory levels, stage of product discretization and other characteristics, which are important regarding lean implementation. To keep anonymity, the names of the case firms are not disclosed. The case industries are:

Case A: Automotive Supplier (B2B type)

Case B: Bearing Manufacturer (B2B type)

Case C: Water purifier manufacturer (B2C type)

Case D: Medical equipment manufacturer (Mix type)

6.2 Case Study Methodology

If the research is exploratory in nature, then the use of statistical inference to generalise from a sample to a larger population could be an appropriate method. However, qualitative research relies on logical inference whereby "case studies are generalisable to theoretical propositions and not populations" (Yin, 1989). The study is mainly focuses on theory development which is primarily exploratory in nature. There are two reasons of selecting the case study research design: first is 'there is little theory regarding the LIBs in SMEs' and another is 'to explore the unforeseen LIBs in most natural context of SMEs.' As the research was not aimed to a specific industry, multiple case studies were conducted and this increases the external validity, (Voss et al. 2002). The cases were chosen from multiple sources (web pages, directory of ministry of MSME India and database of the Confederation of Indian Industries).

The case studies were tested for construct validity and internal validity. Construct validity is the extent to which one establish correct operational measures for the concepts being studied. To ensure construct validity, authors looked for multiple sources of evidence such as interviews with consultants, managers, and employees for each of the important elements in the propositions. The interview protocol is dynamically adjusted to maximise insights into the themes that emerged during the interviews (Eisenhardt, 1989). Use of multiple informants and use of archival data helped authors to crosscheck pertinent information and to verify the reliability of the collected data. A brief description of research aim and expected outcomes were shared with target respondents and confidentiality of sensitive data was ensured. The data were collected through three visits to case sites and unstructured interviews with consultants, managers/owner and workers of the company. Relevant company records and interviews with company consultants were used to collect additional information. To demonstrate the internal validity, the authors recorded evidence of other factors that might be alternative explanations for the observed patterns. Internal validity is the extent to which a causal relationship can be established, whereby certain conditions are shown to lead to other conditions, as distinguished from spurious relationships (Yin, 1989). Data analysis, findings and interpretation have been mainly qualitative in a cross case method.

6.3 Case A: Automotive Supplier (B2B type)

6.3.1 Introduction

Case company A is a manufacturer and supplier of friction products, aluminium die casting products and safety control cables to leading automotive OEMs and Tier 1 vendors. Established in 1989, the company today generates a turnover of over INR 8 Crore. It is certified with QS 9000, ISO 9001:2008, TS 16949:2002, ISO 14001, OHSAS 18001-2007. OEMs have forced this company to adopt lean in their production system as well as in supply chain. The company hired a consultant for lean implementation and some training programs were conducted. One by one company had implemented all suggested practices and took more than four years. After the completion of fifth year, they found a huge increment in their operational performance as well as financial performance. The company faced many challenges during the lean implementation like resistance to change, resource constraints, backsliding to traditional methods.

6.3.2 Product Range

The company provide vide range of automotive products like brake lining, disc brake pad, brake shoe, brake assembly, clutch plates & assembly, aluminium die casting and control cables.

6.3.3 Vision and Mission

The company is committed to deliver the best-in-class products and services that delight the customer's and practice environment-friendly, safe and healthy procedures for prevention of pollution, injury and ill-health. They achieve this through teamwork and initiatives in relentless quest for excellence, total customer orientation and sustainable development. They adopt world-class standards and practices for quality, environment, health and safety management to continually improve the systems and ensure their effective implementation. They regularly review their objectives and targets and communicate these to all employees and stakeholders. They comply with all applicable regulations as manifestation and awareness to be good corporate citizens of the society. Through all these, they make themselves the preferred supply partner of customers.

6.3.4 Lean Assessment

The case company is an automobile supplier, therefore the OEMs force it to adopt lean practices in its production systems and supply chain. The status of lean practices implementation was assessed from multiple sources and as the result of this, it has relatively high level of adoption of lean practices as compared to other cases. The company established long term relationship with the stakeholders and customers gave feedbacks for quality and delivery related issues. Apart from that customers were also actively involved in product development and shared demand information continuously. Likewise, shop floor employees were actively involved in problem solving, process involvement and were provided cross functional trainings. On other hand, the adoption of supplier involvement practices is less compared to other lean practices. The case company adopted pull practices within the production system as well as in supply chain also. It reduces the overall cycle time. With the help of a consultant, the company implementation 5S practices in the organisation and the level of adoption is remarkable. Further, it was found during the case study that the company maintain all equipment regularly and operators were well trained for total productive maintenance and to keep all maintenance record. Additionally, the company adopted other lean practices like statistical process control, Single minute exchange of dies and production levelling to a significant level. But the adoption level of visual management practice is not up to the mark. Here, it has a lot of scope of improvements. The numeric values of the level of adoption of lean practices are discussed in details in Section 6.7.

6.4 Case B: Bearing Manufacturer (B2B type)

6.4.1 Introduction

Case company B produces balls and rollers for different kind of bearings. This ISO 9002 certified SME was established in 1985. Due to global and local competition the company had to reduce prices jeopardising its profitability, and the company decided to adopt lean in the organisation. After 18 months of lean implementation, significant improvements were observed in downtime, rework, setup-time and productivity. The company hired a consultant for lean implementation. The consultant suggested some new machines and automation in the production line. Additionally, they recommended a generator system to avoid the problems of frequent power interruption from the grid. However, due to the lack of financial resources, the management did not procure. As per the consultant's suggestions changes in the work, the system was made. This was followed for some time, but later on most of the workers stepped back to the old system. The owner interested in implementing lean but due to his very busy schedule, most of the times he passed on the responsibility for lean implementation to the supervisors. There was lack of communication between supervisors and workers and also the workers were not taken into confidence resulting in resistance for lean initiatives. They were not satisfied with the work classification system and also they sought additional financial benefits for the extra efforts. The company, however, did not accept. During the interviews, it was revealed that the employees were never asked for suggestions or problems regarding the production process. All this resulted in less involvement of workers in lean implementation.

6.4.2 Product Range

The company is a super-specialist producer of ultra-high-precision rollers for bearings. The performance of a bearing, in terms of its speed, strength & service, to a great extent depends on rollers. The demanding requirements placed on rollers calls for better material, better manufacturing and better micro-geometry. They provide tapered rollers, cylindrical rollers, thrust rollers and spherical rollers.

6.4.3 Vision and Mission

The company has the goal of becoming a prominent taper roller producer of the world and making India the preferred destination, for high-precision products like bearing rollers, in the global market. They belief that in the race for quality there is no finish line. Their corporate philosophy is "To be the best" and they have pursued it with sincerity, courage and insight. Their quality policy Q3 "Quest for Quality in Quantity" has driven them to be a knowledge, design and technology centred organization. They have vigorously pursued innovation and change on several fronts in industry and continue to do the same every day.

6.4.4 Lean Assessment

The case company is a bearing ball and roller manufacturer, it adopted lean practices to sustain in globalized market conditions. The status of lean practices implementation was assessed from multiple sources and as compared to case A, it has relatively low level of adoption of lean practices. As its most of the customer are OEMs, and they forced the company to implement lean practices and their involvement in quality and delivery performance and product development was notable. Its employees were also enthusiastically participating in problem solving and process improvement. They were trained for productive maintenance and keeping record of all maintenance activity. It was found that the suppliers were not giving feedbacks related to quality and delivery and relationships with suppliers were short term basis. Additionally, the level of pull practices and 5S was good enough but relatively lower than case A. The company was using charts for defects and defectives, cause & effect diagram, process capability analysis and techniques for reduction in process variance. Software Minitab 15 was used for the above SPC analysis. With the help of some consultant, the company adopted SMED and production levelling tools to reduce the lead time. Similar to the case A, the adoption level of visual management practice was low. The numeric values of the level of adoption of lean practices are discussed in details in Section 6.7.

6.5 Case C: Water purifier manufacturer (B2C type)

6.5.1 Introduction

Case company C deals with products for water treatment and purification like industrial water treatment plant, industrial water purification plant, water filters, and industrial sewage treatment plant. It is an ISO 9001:2008 company with annual turnover USD 310k-775k. Initially, the company enjoyed monopoly but could not retain its position due to new entrants in the trade. The company adopted lean to reduce the delivery lead time and to improve productivity. Significant improvements were recorded in the second-year of lean implementation, and the firm became more competitive. The top management was actively involved in the lean initiative. Frequent meetings with the employees were held to improve employee involvement. Two training programs were conducted for skill development and to enhance the knowledge of lean tools. The consultant wanted to conduct few more training and skill development programs in the organisation, but due to the resource limitations, the management did not support this suggestion. Initially, employees showed resistance to change due to new work classification system, remuneration system, and the job insecurity but with persuasion, they complied. On the similar grounds, the middle management also did not feel motivated to support the initiative. The problem of employees shifting to their old ways was also faced by the company. After the successful lean implementation on the shop-floor, the company decided to adopt Just-in-Time concept in their supply chain, but due to the lack of involvement of suppliers, this initiative was not successful.

6.5.2 Product range

They provide a wide range of water treatment products such as RO water purifier, softener, DM plant & power products Such as UPS, inverter, and servo voltage stabilize solar products.

6.5.3 Vision and Mission

Their strict adherence to “quality” is the key to the success in the domain. As they are a quality conscious firm, they always strive hard to ensure that the products are in compliance with the industrial standards of quality. They have chosen their purifying systems over the others due to their superior quality and unmatched performance. They offer range undertaking complete stringent quality checks. Their team of quality controllers ensures that only flawless array is delivered to the market offering maximum satisfaction to the clients. They have most modern manufacturing facilities to manufacture the product with a good quality & latest technology up-gradation. The Company believe in quality product manufacturing only and aims to provide the latest technology & reliable products to esteemed customer.

6.5.4 **Lean Assessment**

The case C is a B2C type of organisation and it has no pressure from the customers to adopt lean thinking or some other approach. Its relatively new organisation and its primary aim is to just fulfil the customer demand. The adoption level of lean practices in the case C is lowest among the four case studies considered in the research. As its customers were end users, therefore their involvement in product development and demand information sharing was comparatively less. Though, customers gave feedback on quality and delivery performance but the relationship with customer is weak. The company had young and energetic workforce but the involvement in problem solving and process improvement is ordinary. The reason may be lack of training provided to employees. The company had tried a lot but not able to establish a strong relationship with the suppliers and most of the suppliers were far away from the plant of the company. The company established pull production flow but they didn’t have trained employees. A consultant was hired to implement some lean practices like 5S, TPM and production levelling and the level of adoption of these practices was also significant. The adoption level of SPC and SMED practices was low comparative to other cases but it found significant. On other hand, Visual management practices were hardly used in the case company.

6.6 Case D: Medical equipment manufacturer (Mix type)

6.6.1 **Introduction**

Case D is an ISO 9001 certified company with approximately 100 employees. This is a family owned SME which was established in 1981 and located in western Rajasthan, India. In the 1990s, it enjoyed 15% of market share in India. However, due to the opening of the Indian economy in 1991 the company faced competition from global manufacturers resulting a significant decrease in market share. To retain their market share, the company decided to adopt lean and hired a consultant. Some basic lean practices were implemented in the production process. A lean training program was organised for the employees at all levels. It was followed by the adoption of 5S, visual control, SMED, lot size reduction, statistical process control, quality management programme and production levelling. Eighteen months of lean implementation resulted in decreased cycle time, reduced inventory, and improved productivity. Now, the company is not only able to attract domestic but also international customers.

6.6.2 **Product range**

Case D focuses on two different fields of activities to support the multinational as well as domestic companies with the high quality products. It is engaged in the manufacturing of **Precision Metal Components** and high quality **reusable medical devices**. With over four decades of a strong, customer focused approach and a continuous quest for world class quality they have unmatched expertise across technology, engineering, manufacturing and maintaining a leadership in all major lines of business. It is a manufacturing company, addressing the needs in key sectors - Power, Railway, Defence, Instrumentation etc. – for customers around the world. They cater the needs of companies manufacturing Circuit Breakers, Tap Changers, Induction Furnaces, Brazing & Welding Equipment, Boilers etc.

6.6.3 Vision and Mission

The company strongly believes that business is not only driven by the wide range of products, but the enduring relationship is also an integral part. They always work hard to keep the promises they make to their valuable customers by meeting their expectations both in terms of quality and competitiveness in pricing.

The visionary management, professional executives and skilled workers have piloted the company's march towards prominence. Being an ISO 9001-2008 certified company they strictly adhere to quality assurance system and comply with applicable National & International standards and specifications. With this strive they have now become a preferred source for many reputed organizations.

6.6.4 Lean Assessment

The case D is a mixed type (B2B & B2C) organisation and adopted lean thinking with piecemeal approach. The status of lean practices implementation was assessed from multiple sources and as compared to other cases. The relationship with the customer was good enough but the supplier involvement was not significant. The customer provided feedback on quality and delivery performance but the company rarely gave any feedback to their suppliers. Although employees were well trained for problem solving and process improvement but not motivated for this due to lack of leadership from top management. The adoption level of pull and 5S practices was also significant. They had maintenance schedule and strictly followed it and kept all maintenance data record. To reduce the variation in the production, they adopted statistical process control practices like process capability, charts for defectives and cause & effect diagram. Although they implemented SMED but still they have considerably high set up time. One interesting fact found from the case i.e. for visual management they used many charts for process, demands, standards and more but the shop floor employees were not able to understand these charts. Lastly the production levelling practice was significantly adopted in the plant.

6.7 Cross Case Analysis for Lean assessment:

The level of lean manufacturing practices and issues were assessed in the case companies. The top management and lean consultant of the case companies said that they adopted lean practice in the organisation with piecemeal approach. The reasons of using piecemeal approach are financial limitations, lack of skills and expertise and the organisational culture of the company.

6.7.1 Customer Involvement:

The status of customer involvement in the case companies was assessed from multiple sources and the mean of all sources are reported in Table 6.1 and compared it with the survey findings. Table 6.1 depicts that the overall mean of construct customer involvement for the case companies varies from 3.75 to 6.33 whereas the overall mean of survey for same construct was 5.11. The maximum adoption of customer involvement practices (6.33) was found in case A which was an automotive supplier and B2B type industry. Whereas, in case C minimum adoption of customer involvement practices was found (3.75) which was a water purifier manufacturer and B2C type company. Likewise, overall mean of customer involvement practice for Case B and Case D were found to be 5.96 and 4.79 respectively. Both the case A and case B had higher adoption of customer involvement as compare to other two, because case A and B were the automotive supplier and in an interview, a consultant said that the OEMs forces their suppliers to adopt lean in their production system. As shown in Figure 6.1, the pattern in the radar chart is also similar in both survey and case results. Hence, the case results support the survey findings.

Table 6. 1 Assessment of Customer involvement

Customer Involvement		Mean (Survey)	Mean (Case A)	Mean (Case B)	Mean (Case C)	Mean (Case D)
CI_1	We are in close contact with our customers.	5.73	6.67	6.33	3.5	5
CI_2	Customers give feedback on quality and delivery performance.	4.53	6.33	6.17	3.83	4.33
CI_3	Customers are actively involved in current and future product offerings.	5.55	6.5	5.5	4	5
CI_4	Customers frequently share demand information.	4.64	5.83	5.83	3.67	4.83
Overall mean		5.11	6.33	5.96	3.75	4.79

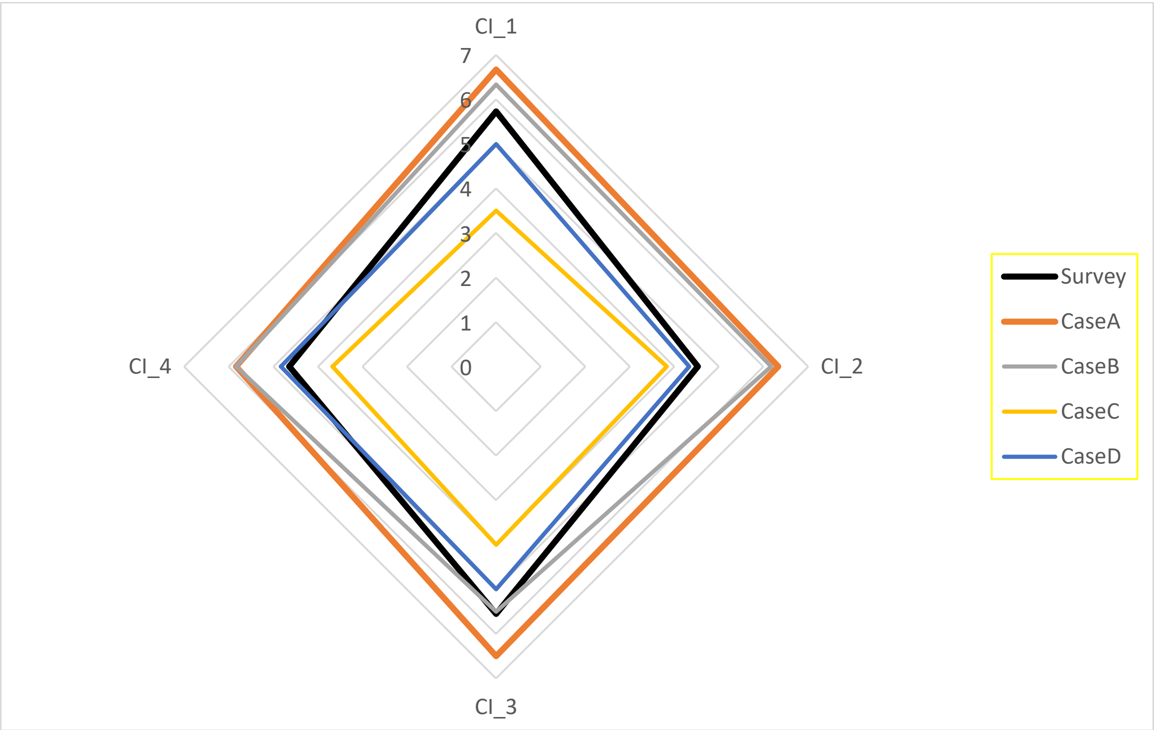

Figure 6. 1 Assessment of Customer involvement

6.7.2 **Employee Involvement**

The status of employee involvement in the case companies was assessed from multiple sources and the mean of all sources are reported in Table 6.2 and compared it with the survey findings. Table 6.2 depicts that the overall mean of items under construct employee involvement varies from 4.17 to 5.13 whereas the overall mean of survey was 4.40. Similar to the construct 'customer involvement', case A and case B having higher overall mean relative to case C and case D. Case C was the newest company among the cases and their employee had less experience and skills also fear of losing jobs. They only do assigned jobs but their involvement in problem solving and process improvement was very low and it was improved after conducting some training programs. On other hand, case A having weekly meeting regarding quality circles, problem solving and process improvement and the workers were actively participated in these activities. The employees are the key contributor in any lean implementation project. As shown in Figure 6.2, the pattern in the radar chart is also similar in both survey and case results. Hence, the case results support the survey findings.

Table 6. 2 Assessment of Employee involvement

Employee Involvement		**Mean (Survey)**	**Mean (Case A)**	**Mean (Case B)**	**Mean (Case C)**	**Mean (Case D)**
EI_1	Shop floor employees are actively involved in problem solving.	4.65	5.67	4.50	4.50	4.33
EI_2	Shop floor employees are actively involved in process improvements.	4.73	5.17	5.50	4.33	4.50
EI_3	Shop floor employees regularly provide suggestions for improvement.	4.18	5.00	5.00	4.00	4.16
EI_4	Shop floor employees undergo cross-functional training.	4.03	4.67	4.83	3.83	4.00
Overall mean		4.40	5.13	4.96	4.17	4.25

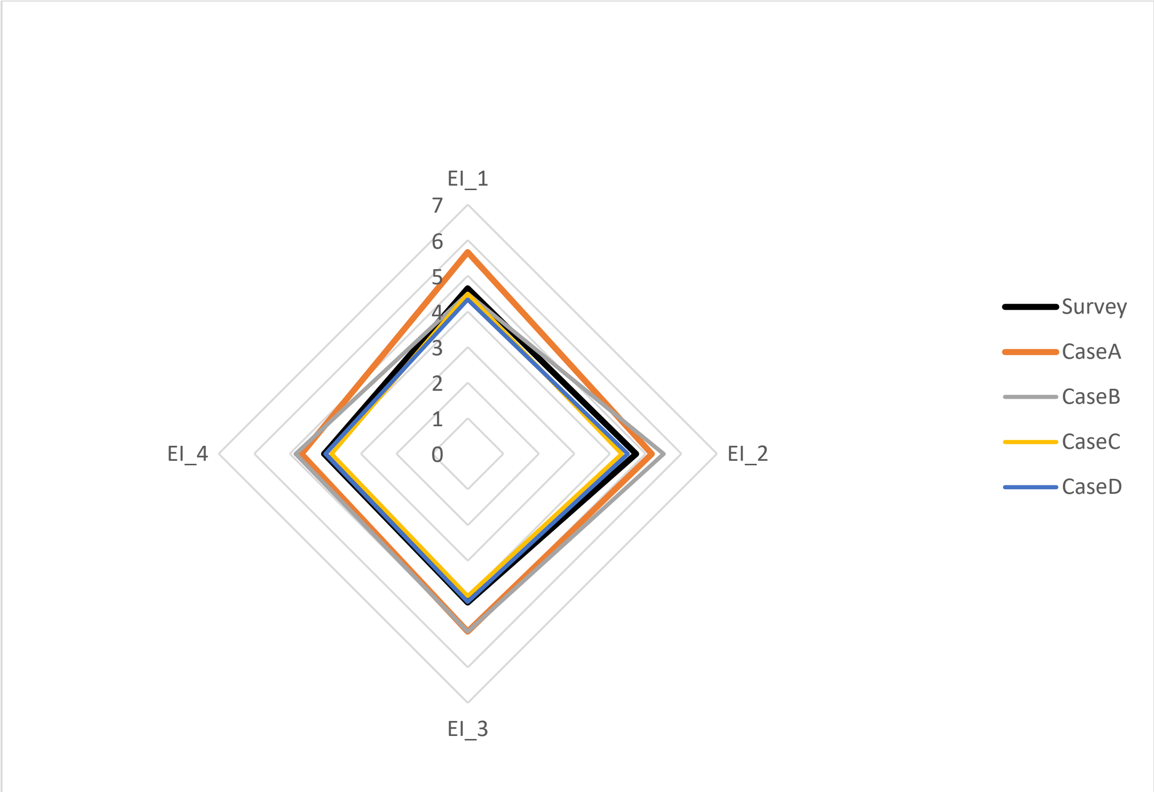

Figure 6. 2 Assessment of Employee involvement

6.7.3 Supplier involvement

The status of supplier involvement in the case company was assessed from multiple sources and the mean of all sources are reported in Table 6.3 and compared it with the survey findings. Table 6.3 depicts that the overall mean of the construct supplier involvement varies from 2.42 to 3.75, which indicates low level of supplier involvement. Overall means of three cases (B, C & D) were below 3.5 which indicates insignificant adoption of supplier involvement practices, whereas, overall mean of case A (3.75) is slightly higher than 3.5. Similarly, the overall mean of survey for same construct was 2.47 which were also insignificant. From the case finding it may be revealed that only automotive suppliers have implemented supplier related practice with a low level adoption. As shown in Figure 6.3, the pattern in the radar chart is also similar in both survey and case results. Hence, the case results support the survey findings. From the above findings, it may be concluded that the SMEs only focuses on customer side not supplier side or lean practices are not implemented throughout supply chain.

Table 6. 3 Assessment of Supplier involvement

Supplier involvement		Mean (Survey)	Mean (Case A)	Mean (Case B)	Mean (Case C)	Mean (Case D)
SI_1	We give our suppliers feedback on quality and delivery performance.	2.51	3.50	2.30	2.33	3.17
SI_2	We strive to establish long-term relationship with our suppliers.	2.47	3.67	2.50	2.17	2.67
SI_3	Our key suppliers are located in close proximity to our plant.	2.43	3.83	2.67	2.50	3.17
SI_4	We take active steps to reduce the number of suppliers in each category.	2.47	4.00	2.67	2.67	3.33
Overall mean		2.47	3.75	2.53	2.42	3.08

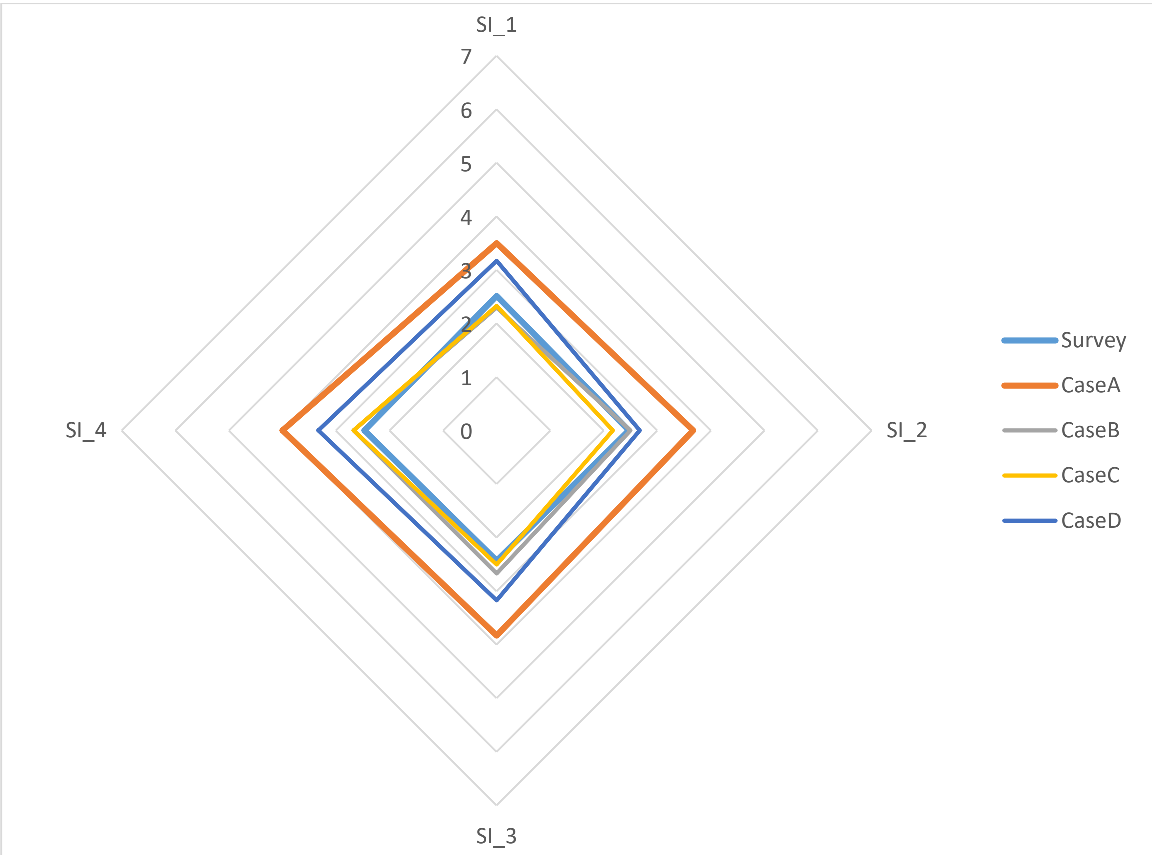

Figure 6. 3 Assessment of Supplier involvement

6.7.4 **Pull System**

The status of Pull system in the case companies was assessed from multiple sources and the mean of all sources are reported in Table 6.4 and compared it with the survey findings. Table 6.4 depicts that the overall means of the construct Pull system varies from 3.54 to 5.24 whereas; the overall mean of survey for same items was 3.56. However, the overall means of all case were above 3.5 but the variation among the cases was high for instance the overall mean for automotive supplier was 5.24 and for water purifier manufacturer was 3.54. The reason of this huge variation may be their different production system. Case A manufactures standard products and has huge demand whereas the case C produces different product every time and demand was low. Likewise, case B and case C also have different production system. As shown in Figure 6.4, the pattern in the radar chart is also similar in both survey and case results. Hence, the case results support the survey findings. Pull is one of the core principles of lean thinking, therefore SME sector should have more focus on the practices related to pull system.

Table 6. 4 Assessment of Pull System

Pull System		**Mean (Survey)**	**Mean (Case A)**	**Mean (Case B)**	**Mean (Case C)**	**Mean (Case D)**
PS_1	Production is pulled by shipment of finished goods.	3.26	4.66	4.33	3.17	3.67
PS_2	Production at workstations is pulled by the demand of the next station.	3.84	5.66	4.83	3.50	4.33
PS_3	We use Kanban, squares or containers of signals for production control.	3.61	5.16	4.5	3.83	4.17
PS_4	We use a pull system to control the production rather than a schedule prepared in advance.	3.53	5.50	4.00	3.67	3.83
Overall mean		3.56	5.24	4.41	3.54	4

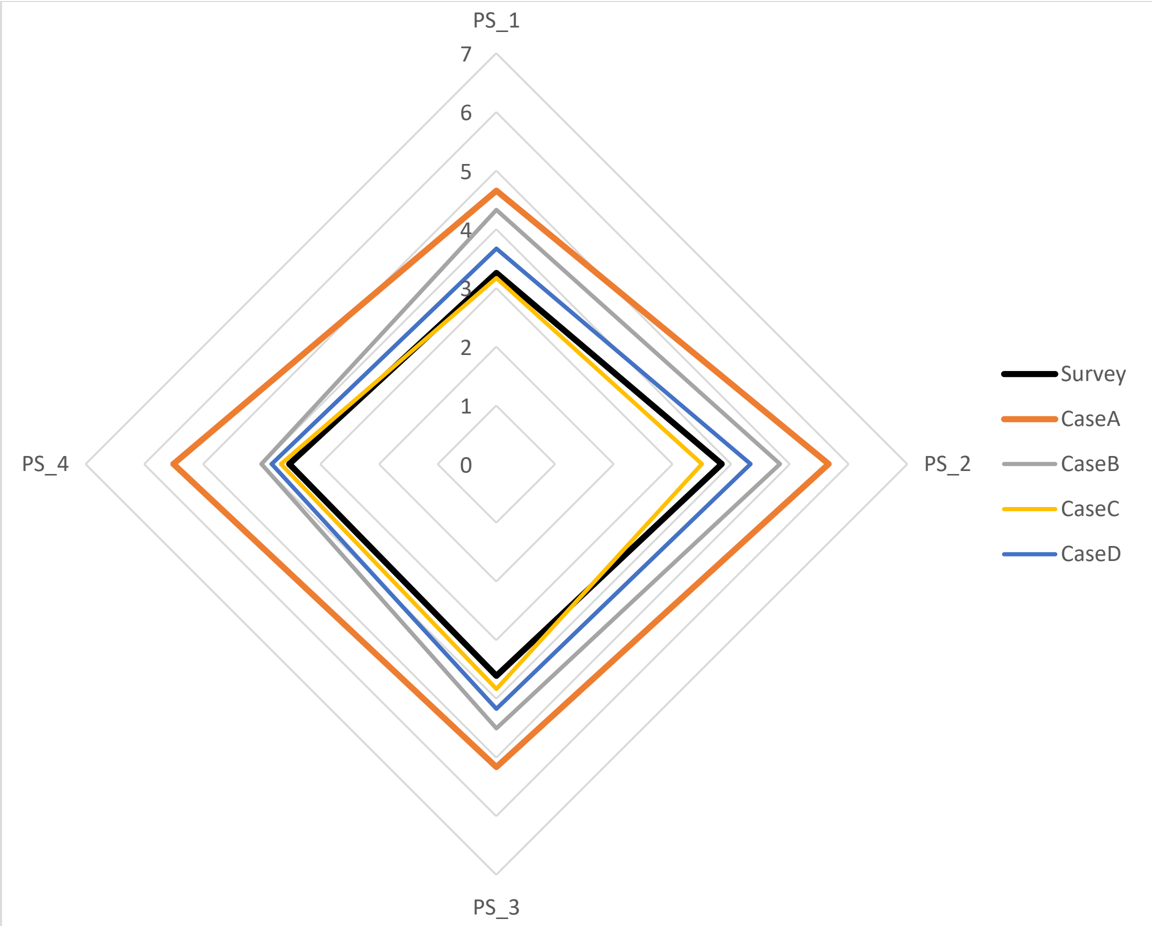

Figure 6. 4 Assessment of Pull System

6.7.5 **5S**

The status of 5S in the case companies was assessed from multiple sources and the mean of all sources are reported in Table 6.5 and compared it with the survey findings. Table 6.5 depicts that the overall means of the construct 5S varies from 4.46 to 5.57 whereas, the overall mean of survey for same construct was 4.66. It may be revealed from the case findings that the adoption of 5S practices was relatively high for all the cases as well as survey results. Therefore, the level of 5S practices in Indian SMEs is very good. Case A has highest adoption level whereas Case C has lowest and Case B and D were intermediate. As shown in Figure 6.5, the pattern in the radar chart is also similar in both survey and case results. Hence, the case results support the survey findings.

Table 6. 5 Assessment of 5S

5S		Mean (Survey)	Mean (Case A)	Mean (Case B)	Mean (Case C)	Mean (Case D)
5S_1	Only the materials which are actually needed are present in the work area.	4.74	5.50	5.00	3.83	4.83
5S_2	Only tools and hand tools which are needed are present in the work area.	4.97	5.83	5.33	4.50	5.00
5S_3	Locations for all production materials are clearly marked out and the materials are stored in the correct locations. Areas for WIP (work-in-process parts) are clearly marked.	4.12	5.00	4.83	4.33	4.67
5S_4	Work areas, storage areas, aisles machines, tools, equipment and offices are clean/neat and free of safety hazards.	4.73	5.33	5.00	4.83	4.83
5S_5	Regularly scheduled housekeeping tours and periodic self- assessments (5S audits) are conducted.	4.75	5.67	5.33	4.83	4.67
Overall mean		4.66	5.47	5.10	4.46	4.80

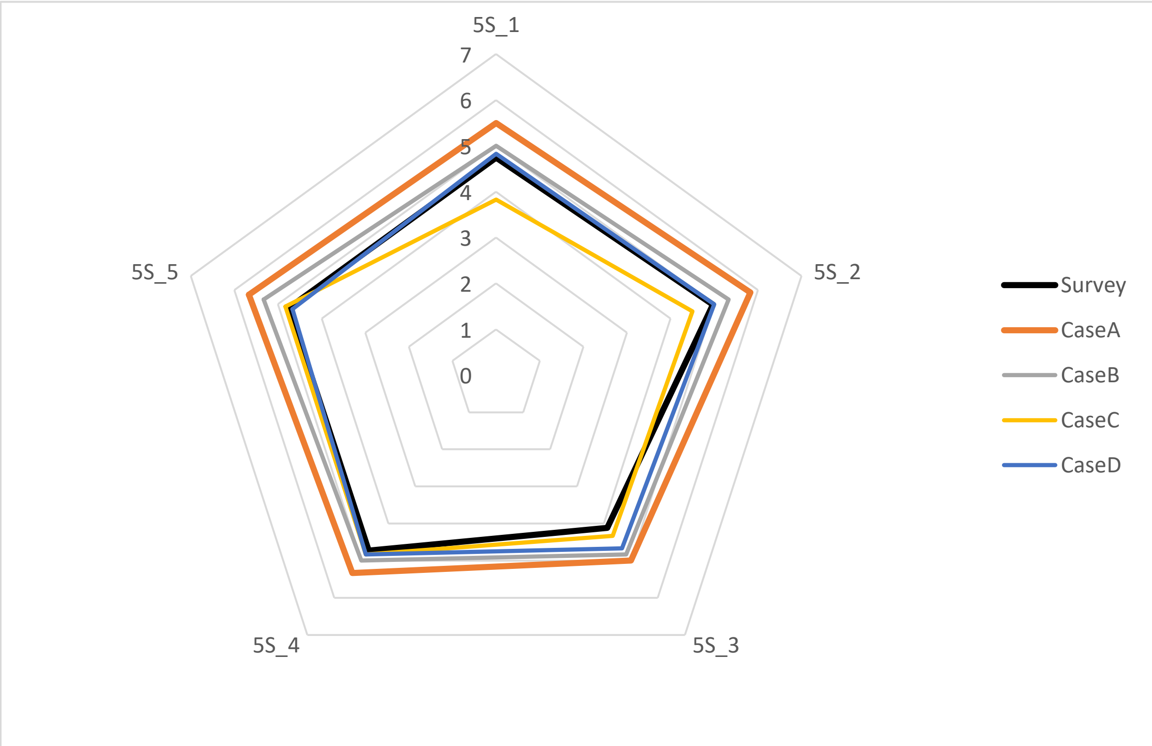

Figure 6. 5 Assessment of 5S

6.7.6 Total Productive Maintenance (TPM)

The status of TPM in the case companies was assessed from multiple sources and the mean of all sources are reported in Table 6.6 and compared it with the survey findings. Table 6.6 depicts that the overall mean of the construct TPM varies from 4.38 to 5.54 whereas, the overall mean of survey for same construct was 4.9. The high value of overall means in the cases and survey results, confirms the high level of TPM practices adoption in the SME sector but still, there is an opportunity of improvement. Similar to other constructs, the adoption of TPM is highest in case A i.e. automotive supplier and lowest in case C. The variation of case A, case B, and case D is very low which indicates that the TPM practices may not be dependent on the type of production system. TPM practices confirms the uninterrupted production that's why it is a crucial construct for the lean thinking and it became more critical in case of SMEs where the resources are limited. As shown in Figure 6.6, the pattern in the radar chart is also similar in both survey and case results. Hence, the case results support the survey findings.

Table 6. 6 Assessment of TPM

Total Productive Maintenance (TPM)		**Mean (Survey)**	**Mean (Case A)**	**Mean (Case B)**	**Mean (Case C)**	**Mean (Case D)**
TPM_1	We maintain all our equipment regularly.	4.30	5.00	4.83	4.00	4.5
TPM_2	We maintain records of all equipment maintenance activities.	4.96	5.33	4.50	4.67	4.67
TPM_3	We ensure that machines are in high state of readiness for production at all the time.	5.21	5.83	4.83	4.33	5.00
TPM_4	Operators are trained to maintain their own machines.	5.24	6.00	5.33	4.50	5.33
	Overall mean	4.93	5.54	4.87	4.38	4.88

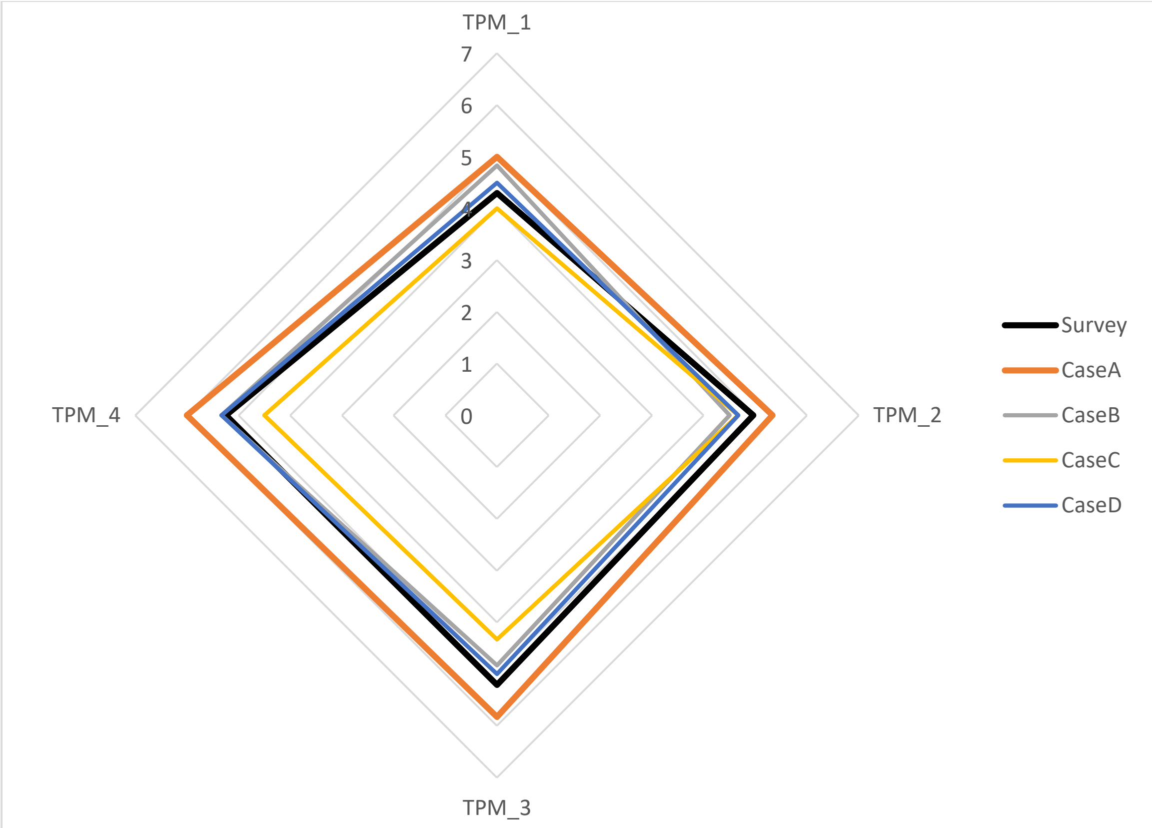

Figure 6. 6 Assessment of TPM

6.7.7 Statistical Process Control (SPC)

The status of SPC in the case companies was assessed from multiple sources and the mean of all sources are reported in Table 6.7 and compared it with the survey findings. Table 6.7 depicts that the overall mean of the construct SPC varies from 3.92 to 4.92 whereas, the overall mean of survey for the same construct was 4.57. The case A get highest overall mean (4.92) that indicates the highest level of adoption of SPC practices. On the other hand, case C has the lowest overall mean (3.92), it indicates the lowest level of adoption of SPC practices. Likewise, the overall means of case B and case D are 4.58 and 4.50 respectively. The difference between the case B and case D with respect to adoption of SPC practice is very less. It may be concluded from the findings in table 6.7, that the level of adoption of SPC practices is less in B2C type of organisations as compared to B2B type of organisations. In contrast, the level of adoption of SPC practices in automotive suppliers is high. As shown in Figure 6.7, the pattern in the radar chart is also similar in both survey and case results. Hence, the case results support the survey findings.

Table 6. 7 Assessment of SPC

Statistical Process Control (SPC)		Mean (Survey)	Mean (Case A)	Mean (Case B)	Mean (Case C)	Mean (Case D)
SPC_1	Charts showing defects are used as tools on the shop floor.	4.55	5.00	4.83	4.00	4.50
SPC_2	We use diagrams like cause & effects (fishbone) to identify causes of quality problems	4.12	4.67	4.33	3.83	4.50
SPC_3	We conduct process capability studies before product launch.	4.81	5.17	4.67	3.50	4.33
SPC_4	We use statistical techniques to reduce process variance.	4.80	4.83	4.50	4.33	4.67
Overall mean		4.57	4.92	4.58	3.92	4.50

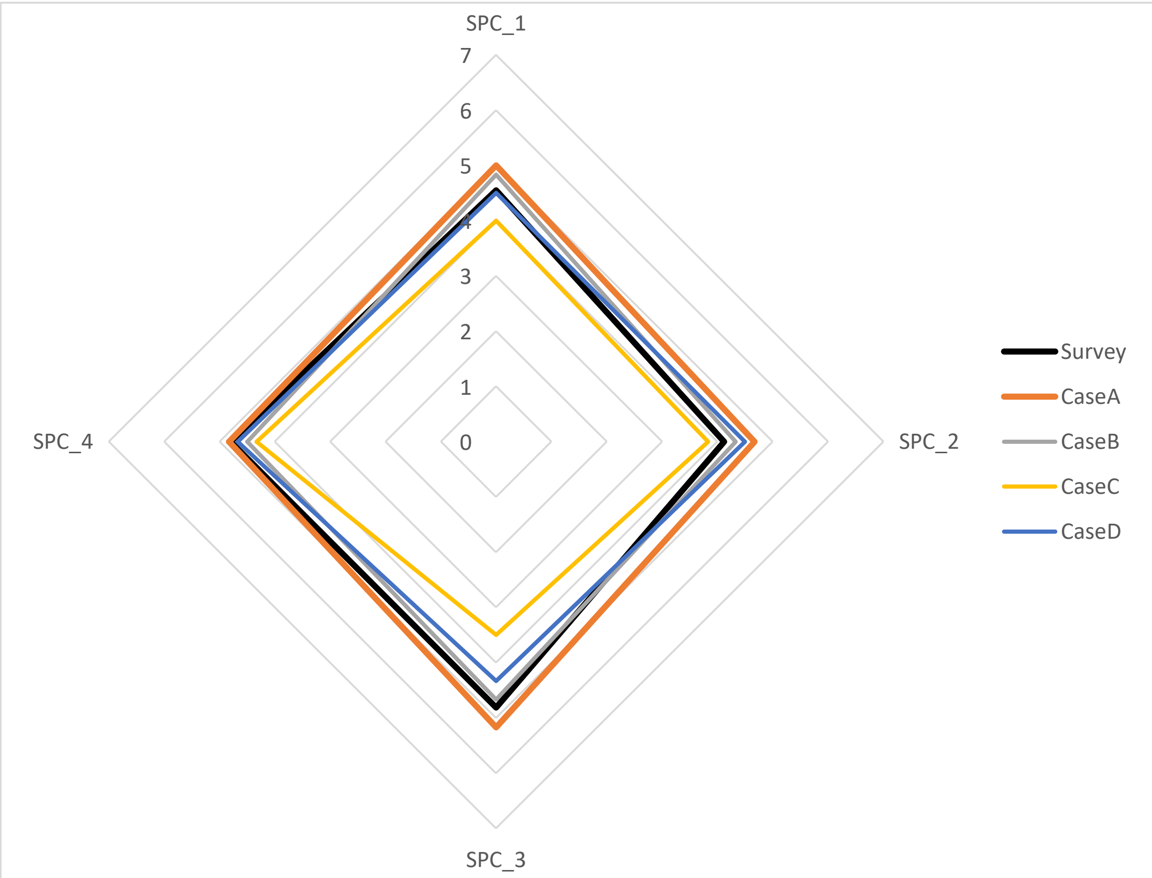

Figure 6. 7 Assessment of SPC

6.7.8 Single minute exchange of dies (SMED)

The status of SMED in the case companies was assessed from multiple sources and the mean of all sources are reported in Table 6.8 and compared it with the survey findings. Table 6.8 depicts that the overall mean the construct SMED varies between 3.77 to 4.90 whereas, the mean of survey for same items are 3.84. The results of case studies are not in line with survey findings because the overall means of case A (4.90) and case B (4.87) are very high with respect to the survey overall mean (3.84). Whereas the overall means of case C (3.77) and case D (3.93) are very close to the survey overall mean (3.84). As shown in Figure 6.8, the pattern in the radar chart is also similar in both survey and case results. Hence, the case results support the survey findings.

Table 6. 8 Assessment of SMED

Single minute exchange of dies (SMED)		**Mean (Survey)**	**Mean (Case A)**	**Mean (Case B)**	**Mean (Case C)**	**Mean (Case D)**
SMED_1	We are working to lower set-up time in our plant	3.42	5.00	5.00	3.67	3.50
SMED_2	We have short set-up times for equipment in our plant	4.15	5.17	4.83	4.33	4.50
SMED_3	Operators perform their own machines set-ups.	3.83	4.67	5.00	4.00	4.33
SMED_4	Operators are trained on machine set-up activities.	3.92	4.83	4.83	3.33	3.67
SMED_5	We emphasize the need to place all tools in a convenient area to the operator.	3.86	4.83	4.67	3.50	3.67
Overall mean		3.84	4.90	4.87	3.77	3.93

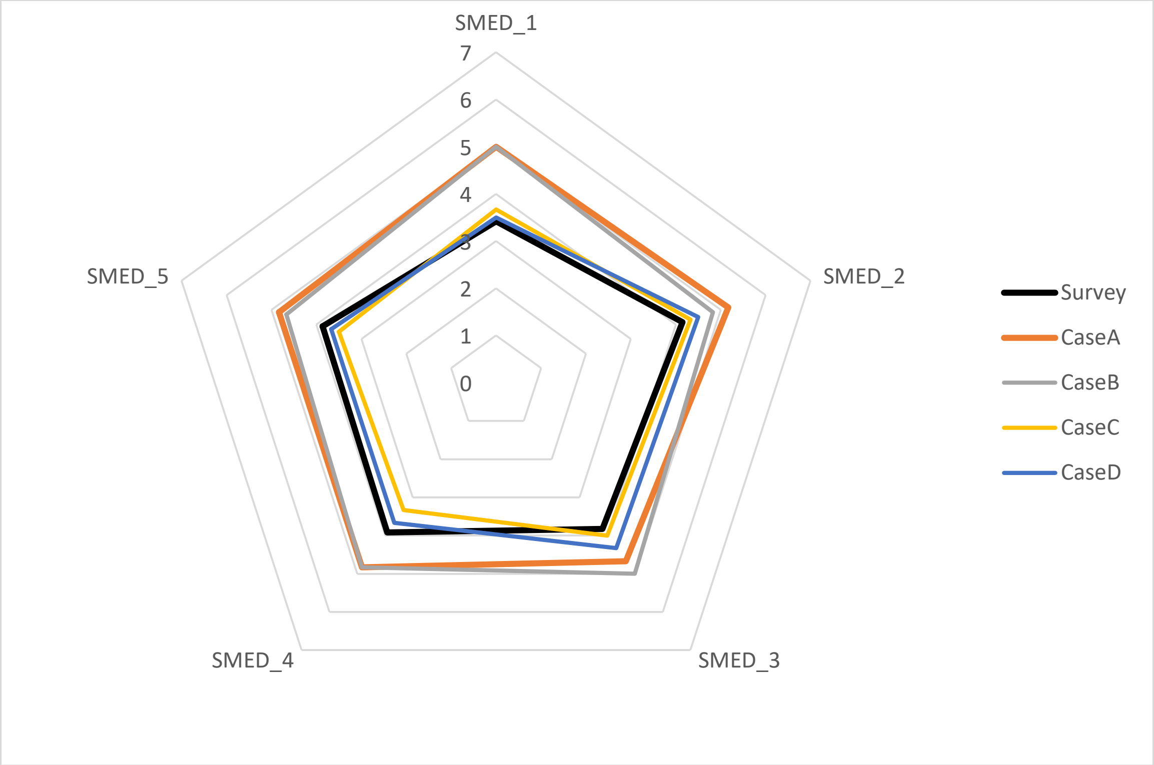

Figure 6. 8 Assessment of SMED

6.7.9 **Visual management (VM)**

The status of Visual management in the case companies was assessed from multiple sources and the mean of all sources are reported in Table 6.9 and compared it with the survey findings. Table 6.9 depicts that the overall mean construct Visual management varies between 3.11 to 3.78, which is very low as compared to other constructs whereas, the overall mean of survey for same items is 3.15. The results of case studies and survey both indicates that the adoption of Visual Management practices are very low. Only the one case (case A) has the overall mean above 3.5. Hence, it may be concluded that the adoption of visual management practices in SME sector is low and needs to improve it. It is noted that the means for case study as well as survey both are below 3.5 that indicates that the adoption of visual management practices are low.

In case A, the top management executive said that they have adopted the visual management practices with a very high level of adoption but the employee didn’t agree with this. When this contradictory statement was investigated it was found that the company have mounted many charts to shows the right process, performance parameters, demand information and many more things but the employee were not able to understand these charts. As shown in Figure 6.9, the pattern in the radar chart is also similar in both survey and case results. Hence, the case results support the survey findings.

Table 6. 9 Assessment of Visual management

Visual management		Mean (Survey)	Mean (Case A)	Mean (Case B)	Mean (Case C)	Mean (Case D)
VM_1	Equipment are identified with signages	3.20	3.83	3.50	3.17	3.5
VM_2	Process parameters are displayed on the shop floor.	3.13	3.50	3.17	3.00	3.33
VM_3	Manufacturing performance is displayed on the shop floor.	3.12	4.00	3.67	3.17	3.17
Overall mean		3.15	3.78	3.45	3.11	3.33

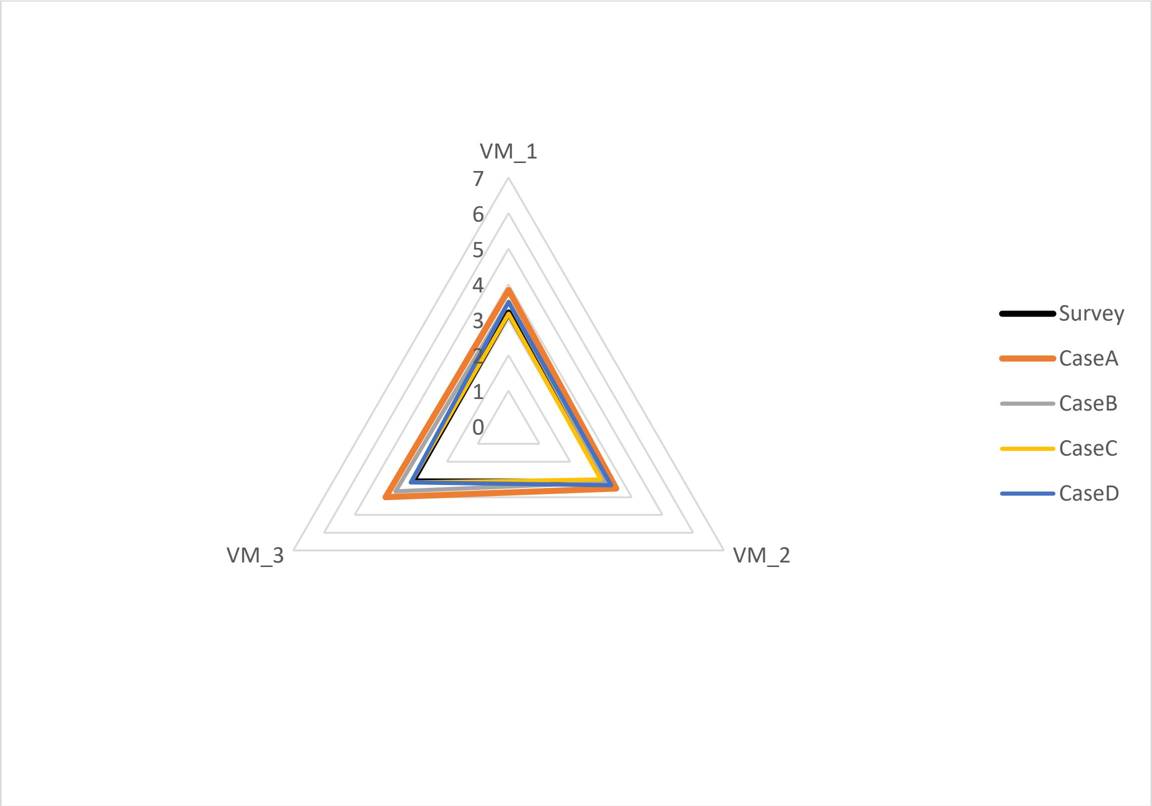

Figure 6. 9 Assessment of Visual management

6.7.10 **Production levelling (PL)**

The status of Production levelling in the case companies was assessed from multiple sources and the mean of all sources are reported in Table 6.10 and compared it with the survey findings. Table 6.10 depicts that the overall mean of construct Production levelling in case companies varies from 4.28 to 5.50 whereas, the overall mean of survey was 4.60. The two cases (case A and case B) have overall means above 5.00 whereas, other two cases (case C and case D) have overall mean above 4.00. These results confirm the high level of adoption of production levelling practices in Indian SMEs. The B2B type of companies (case A and B) have high adoption level of production levelling practices compared to B2C or mixed type of SMEs. As shown in Figure 6.10, the pattern in the radar chart is also similar in both survey and case results. Hence, the case results support the survey findings.

Table 6. 10 Assessment of Production levelling

Production levelling		**Mean (Survey)**	**Mean (Case A)**	**Mean (Case B)**	**Mean (Case C)**	**Mean (Case D)**
PL_1	We mix production on the same machines and equipment..	4.47	5.00	4.83	4.00	4.67
PL_2	We emphasize the need for an accurate forecast to reduce variability in production.	5.05	5.33	5.00	4.33	5.00
PL_3	Each product is produced in a relatively fixed quantity per production period.	4.15	5.50	5.00	4.00	4.17
PL_4	We emphasize the need to equalize workloads in each production process.	4.15	5.33	4.67	4.17	4.33
PL_5	We produce by repeating the same combination of products from day to day.	4.49	5.83	5.33	4.33	4.50
PL_6	We always have some quantity of every product model to respond to variation in customer demand.	5.29	6.00	5.5	4.83	5.33
Overall mean		4.60	5.50	5.06	4.28	4.67

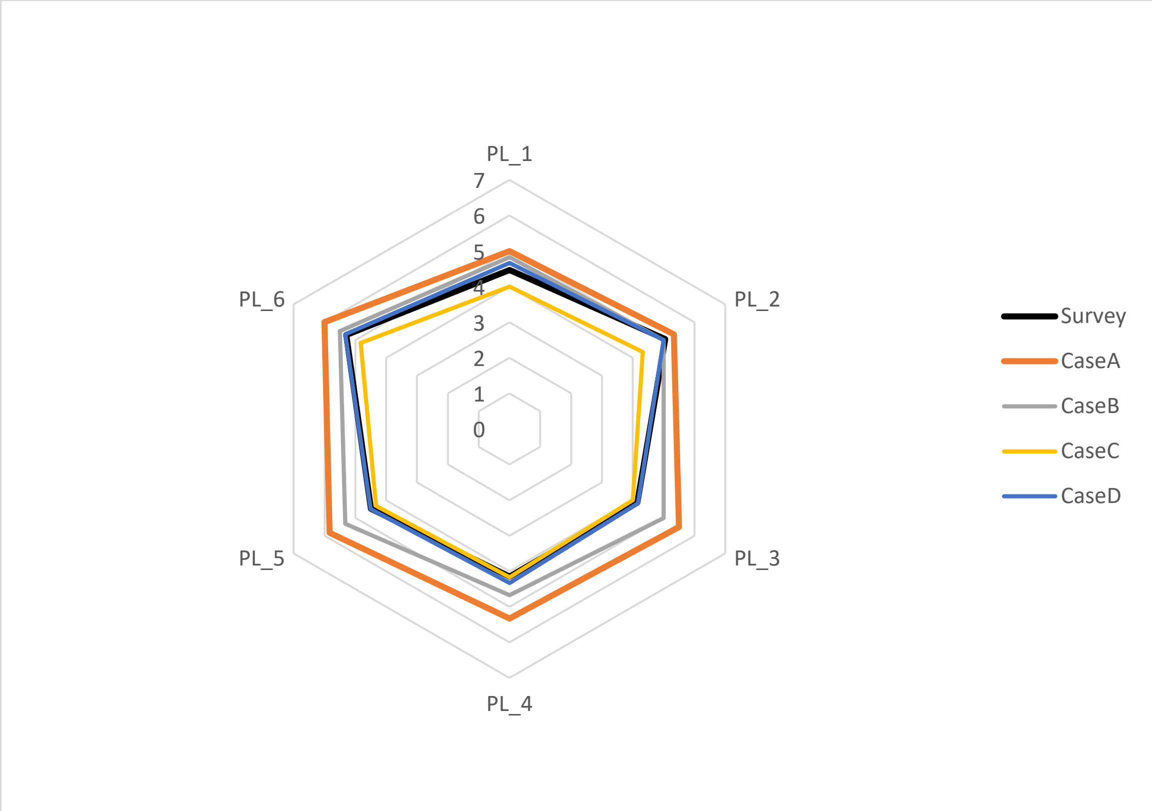

Figure 6. 10 Assessment of Production levelling

6.8 Barriers to lean implementation (LIBs)

For the fruitful adoption of lean in SMEs, effective management of lean implementation barriers (LIBs) is critical (Achang *et al.* 2006; Bhasin 2012; Dora *et al.* 2016). According to an estimate, merely 10% of organisations have successfully adopted lean practices (Bhasin and Burcher 2006). Ineffective management of LIBs could be a reason for such scant successful implementation (Dora *et al.* 2013). Furthermore, according to Jadhav *et al.* (2014), barriers not only affect the implementation of lean but also influence one another.

Here, an attempt is made to identify the LIBs for SMEs and to develop a hierarchical model which demonstrates the interrelationship between the LIBs. Three case studies were conducted to identify the LIBs. Further, ISM method is used to model the LIBs. This section describes the barriers to implementation lean in SMEs identified through the exploration of literature on large enterprises and the three case studies mentioned in this study. Case C has not participated in this work because of the confidentiality of the firm and rest of the three cases have actively involved in this study. The barriers to implement lean are summarised in Table 6.11. For convenience, LIBs are coded as B1, B2, … , and B10. The symbol "√" denotes the presence of the barrier in the case and symbol "-" indicates the absence of the barrier in the case. It is noted that out of these ten barriers seven- B2, B3, B4, B6, B7, B8, and B9 are present in all the cases. The LIBs are discussed next.

6.8.1 **Lack of Management Commitment and Leadership:**

Management commitment is a key ingredient for the success of any new initiative. Lack of management commitment leads to a swarm of other problems, like restricted access to resources, delays in decision-making processes and improper communication (Scherrer-Rathje *et al.*, 2009). Lean implementation strictly requires consistent involvement, encouragement, and supervision of the top management (Panizzolo *et al.* 2012; Hu *et al.* 2015; Abolhassani *et al.* 2016). Top management has to set vision, strategy, goals and a direction to keep the project (Jadhav *et al.* 2014). Especially in SMEs context, this factor is highly relevant due to the direct involvement of top management in regular operations, direct supervision, and deliveries. Owner (having responsibilities of HR, marketing, and production) one of the case companies said

"*In the initial phase of implementation, I was doubtful about the benefits of lean and the success of this project. For this reason, I was not actively involved in this.*"

Table 6. 11 Barriers to implement lean

	LIBs	Case A	Case B	Case D
B1	Lack of management commitment and leadership	✓	–	✓
B2	Organisational culture	✓	✓	✓
B3	Lack of communication	✓	✓	✓
B4	Lack of resources	✓	✓	✓
B5	Resistant to change	–	✓	✓
B6	Lack of Employee involvement	✓	✓	✓
B7	Lack of training and skills	✓	✓	✓
B8	Lack of understanding lean benefits (measuring benefits)	✓	✓	✓
B9	Backsliding to old methods	✓	✓	✓
B10	Lack of supplier involvement	✓	✓	–

6.8.2 **Organisational Culture**

The culture of an organisation may be defined as rule and behaviours which cover trust, hierarchy, working environment, and fellow-feeling (Dora *et al.* 2016). The organisational culture of an SME reflects the personality or attitude of top executives. According to Achanga et al. (2006) and Dora et al. (2016), organisational culture is crucial for lean implementation. Supportive organisational culture act like an encouraging platform for the lean implementation (Achanga et al. 2006). On the other hand, if the trust, working environment, and fellow-feeling are deficient in the organisation then organisational culture becomes a major LIB. All the three cases revealed the importance of organisational culture in the success of lean initiatives.

6.8.3 **Lack of Communication**

Effective communication between all levels of organisational hierarchy as well as between internal and external stockholders is mandatory for any management initiatives including lean. It works as cement between bricks. A proper communication within the organisation and between its stakeholders is the key success factor for lean implementation (Scherrer-Rathje *et al.*, 2009; Timans *et al.* 2012). During the interview, the supervisor of the case company expressed that:

"*There was a lot of communication gap between top management, middle management, and workers. The management transferred the information related to production to the shop-floor level. They did not, however, communicate any information related to lean implementation; only the consultant did.* "

6.8.4 **Lack of resources**

Lack of financial, technical and human resources is considered as a prominent barrier in lean implantation. According to Eswaramoorthi *et al.* (2011) lack of time, workforce and funds have been attributed for the meagre adoption of lean in SMEs. An adequate amount of resources are required for the successful implementation of lean (Chaplin *et al.* 2016; Achanga *et al.* 2006). Consultant for lean implementation in the case SMEs expressed the need for resources as:

"Case SMEs had more capabilities than they achieved from lean implementation but the big constraint was lack of resources. Due to this reason, the company missed many opportunities for improvements."

6.8.5 **Resistant to change**

The sudden introduction of new methods makes employees uncomfortable because they are more comfortable with the traditional methods. The middle management and shop-floor workers provide a 'resistance to change' during lean implementation (Marodin and Saurin 2015; Jadhav *et al.* 2014; Bhasin 2012). The reasons for resistance to change, however, may be different for managers and workers. Fear of failure was found to be of concern among managers while workers were more apprehensive about their jobs (Jadhav *et al.* 2014). Similar observations were made in all the case SMEs. Lack of knowledge about lean may also create a negative mindset of employees.

6.8.6 Lack of employee involvement

Successful lean transformation requires direct involvement of employees in setting organizational vision, goals, and values. Participation of employees increases the flow of knowledge and information and contributes to problem-solving as well. Involvement of employees and management acts as cement in the wall. Lack of employee involvement, make lean implementation process tedious and unfruitful (Panizzolo *et al.* 2012; Wong and Wong 2011; Cudney and Elrod 2010.

6.8.7 Lack of training and skills

Trained and skilled employees are considered as an asset to the industry. For the successful lean implementation, training of managers and workers is strictly required to enhance the basic knowledge of lean (Dora *et al.* 2016; Hu *et al.* 2015). In case of SMEs, lack of training and skills was considered to be one of the reasons for a low degree of lean implementation. The case SMEs avoided some training programs due to the financial and time constraints.

6.8.8 Lack of understanding of lean benefits

It is argued that if the benefits of any new initiatives are clear to the stack holders, they become motivated towards the adoption of the initiative. Additionally, measurement of improvements also motivates the stakeholders (Bhasin 2012). Executives of case companies accepted that they didn’t have enough knowledge about the benefits of lean implementation. It was also revealed in the cases that motivation was low in the starting phase of lean implementation, but it improved once improvements were observed. A consultant mentioned that

"In the first phase of implementation, the involvement of management and employees were very low. But once we measured the improvements and showed to the top executives; motivation level went up considerably."

6.8.9 Backsliding to old methods

One of the barriers to lean implementation is backsliding to old methods in anticipation that the improvement in the productivity results in unemployment (Wong and Wong 2011; Emiliani and Stec 2005). According to Wong *et al.* (2009), the major problem in lean implementation is the propensity to revert to traditional practices when difficulties were encountered. In the case studies also, it was revealed that the supervisors and workers stuck to their old methods and they did not follow the new methods suggested by the consultants.

6.8.10 Lack of supplier involvement

To survive and grow in today's competitive environment suppliers should act as a seamless extension of the organisation (Dey *et al.* 2015; Yadav *et al.* 2018c; Yadav and Sharma 2015a; Yadav and Sharma 2015b). It is necessary to extend the lean implementation to their supply chain partners, but according to Abdul-Nour *et al.* (1998), it is difficult for SMEs to develop a lean supply chain. SMEs suffer from lack of cooperation with their suppliers (Salaheldin 2005). Two out of three case studies revealed that the suppliers were not actively involved in the lean implementation.

6.9 ISM Model for LIBs

After the identification of lean implementation barrier in SMEs, the next step was to develop the relationship between them. Interpretive Structural Modelling (ISM) was used to establish the relationship among LIBs. It is considered as a powerful tool to develop the structural model for the attributes. An expert team was formed consisting of four academicians (two professors, one associate professor, and one lecturer) having Ph.D. in the lean domain and three practitioners (owners of the SMEs). This team critically analysed the various extracted LIBs in SMEs in context to lean implementation. Subsequently, the relationships among the LIBs were established. These relationships helped in forming structural self-interaction matrix and to carry out further analysis. The steps involved in ISM method are explained in the following:

- List the barriers extracted from the literature and the cases.
- Define the contextual relationship between barriers from the extensive discussion with the expert team.
- Develop the SSI matrix for barriers with the help of contextual relationship between barriers. In SSI matrix, pair-wise contextual relationships are expressed in the form of V,A,X and O. (V = barrier I will lead to j, A = barrier j will lead to i, X = barrier i and j will lead to each other, and O = barrier i and j are not related)
- Develop the initial reachability matrix from SSI matrix by converting information in cells into binary form.
- Develop the final reachability matrix by considering the transitivity in initial reachability matrix.
- Develop the level partitioning table consisting of the reachability set and the antecedent set.
- Draw a directed graph (called ISM model) based on the above relationship and remove the transitivity links.
- Finally, review the ISM model for inconsistency and modifications through the expert team.

The team of experts studied the cases and validated the various LIBs. They provided the relationship between barriers which helped in developing the structural self-interaction matrix (SSIM). The SSIM is presented in Table 6.12. Further, the SSIM was converted into a binary form which is called the initial reachability matrix (RM). The conversion into binary form was performed by the following rules given below:

- If the entry (i,j) is V in SSIM, then the corresponding entry in (i,j) will be 1 and entry in (j,i) will be 0.
- If the entry (i,j) is A in SSIM, then the corresponding entry in (i,j) will be 0 and entry in (j,i) will be 1.
- If the entry (i,j) is X in SSIM, then the corresponding entry in (i,j) will be 1 and entry in (j,i) will be 1.
- If the entry (i,j) is O in SSIM, then the corresponding entry in (i,j) will be 0 and entry in (j,i) will be 0.

Following the above convention, the initial RM was prepared (Table 6.13). The final RM was developed by considering the transitivity and the again discussion with the experts. Transitivity states that if barrier *a* is related to *b* and *b* is related to *c*, then *a* is necessarily related to *c*. Final matrix was further checked and corrected by the expert team. Then final RM was obtained and presented in Table 6.14. Further to develop the levels of the barrier in the hierarchy model, the level partitioning was performed. The reachability sets and antecedents sets for each barrier were identified. The reachability sets consist of the barrier itself and the barrier which it may help to achieve. The antecedents sets consist the barrier itself and the barrier which may help to achieve it. Then the intersection set was drawn for each barrier. The barriers for which the reachability set and intersection set had the same values were given the top-level variable in the model. These top-level barriers in the model would not help in achieving other barriers. These barriers were then removed from the list of barriers, and the process was repeated until all barriers were assigned their level. It can be seen from the Table 6.15 that there are total six levels for ten barriers. Once the levels of barrier are found, the next step is building the final structural model. The final ISM was obtained by removing all transitivity links as shown in Figure 6.11.

Table 6. 12 Structural self-interaction matrix

	B10	B9	B8	B7	B6	B5	B4	B3	B2
B1	V	V	X	V	V	V	V	X	V
B2	O	V	O	A	A	V	O	O	
B3	O	V	V	A	X	V	O		
B4	O	O	O	V	O	O			
B5	O	V	X	X	X				
B6	O	V	O	X					
B7	O	O	V						
B8	O	V							
B9	O								
B10									

Table 6. 13 Initial Reachability Matrix

	B1	B2	B3	B4	B5	B6	B7	B8	B9	B10
B1	1	1	1	1	1	1	1	1	1	1
B2	0	1	0	0	1	0	0	0	1	0
B3	1	0	1	0	1	1	0	1	1	0
B4	0	0	0	1	0	0	1	0	0	0
B5	0	0	0	0	1	1	1	1	1	0
B6	0	1	1	0	1	1	1	0	1	0
B7	0	1	1	0	1	1	1	1	0	0
B8	1	0	0	0	1	0	0	1	1	0
B9	0	0	0	0	0	0	0	0	1	0
B10	0	0	0	0	0	0	0	0	0	1

Table 6. 14 Final Reachability Matrix

	B1	B2	B3	B4	B5	B6	B7	B8	B9	B10
B1	1	1	1	1	1	1	1	1	1	1
B2	0	1	0	0	1	1*	1*	0	1	0
B3	1	0	1	0	1	1	1*	1	1	1*
B4	0	0	1*	1	0	0	1	0	0	0
B5	0	1*	1*	0	1	1	1	1	1	0
B6	0	1	1	0	1	1	1	0	1	0
B7	1*	1	1	0	1	1	1	1	1*	1*
B8	1	1*	0	0	1	1*	1*	1	1	1*
B9	0	0	0	0	0	0	0	0	1	0
B10	0	0	0	0	0	0	0	0	0	1

Table 6. 15 Level-Partitioning

	Rechability Set	Antecedent set	Intersection	Level
B1	1,2,3,4,5,6,7,8,9,10	1,3,7,8	1,3,7,8	VI
B2	2,5,6,7,9	1,2,5,6,7,8	2,5,6,7	II
B3	1,3,5,6,7,8,9,10	1,3,4,5,6,7	1,3,5,6,7	IV
B4	3,4,7	1,4	4	V
B5	2,3,5,6,7,8,9	1,2,3,5,6,7,8	2,3,5,6,7,8	II
B6	2,3,5,6,7,9	1,2,3,5,6,7,8	2,3,5,6,7	II
B7	1,2,3,5,6,7,8,9,10	1,2,3,4,5,6,7,8	1,2,3,5,6,7,8	II
B8	1,2,5,6,7,8,9,10	1,3,5,7,8	1,5,7,8	III
B9	9	1,2,3,5,6,7,8,9	9	I
B10	10	1,3,7,8,10	10	I

Figure 6.11 shows that 'lack of management commitment and leadership,' 'lack of resources' and 'lack of communication' are placed at sixth, fifth and fourth levels respectively. Thus these three barriers are key LIBs in SMEs. It is noted that 'lack of management commitment and leadership' and 'lack of communication' are key LIBs for large enterprises also (Jadhav *et al.* 2014; Bhasin 2012). It is further noted that 'lack of resources' is found to be an important barrier in SMEs unlike in large enterprises. As per ISM, 'backsliding to old methods' and 'lack of supplier involvement' are found to be less important barriers in SMEs. The barriers 'lack of understanding of lean benefits,' 'organisational culture,' 'resistance to change,' 'lack of employee involvement' and 'lack of training and skills' are of the intermediate level showing medium importance. Further to know the degree of relationships (driving power and dependence power) MICMAC analysis is performed.

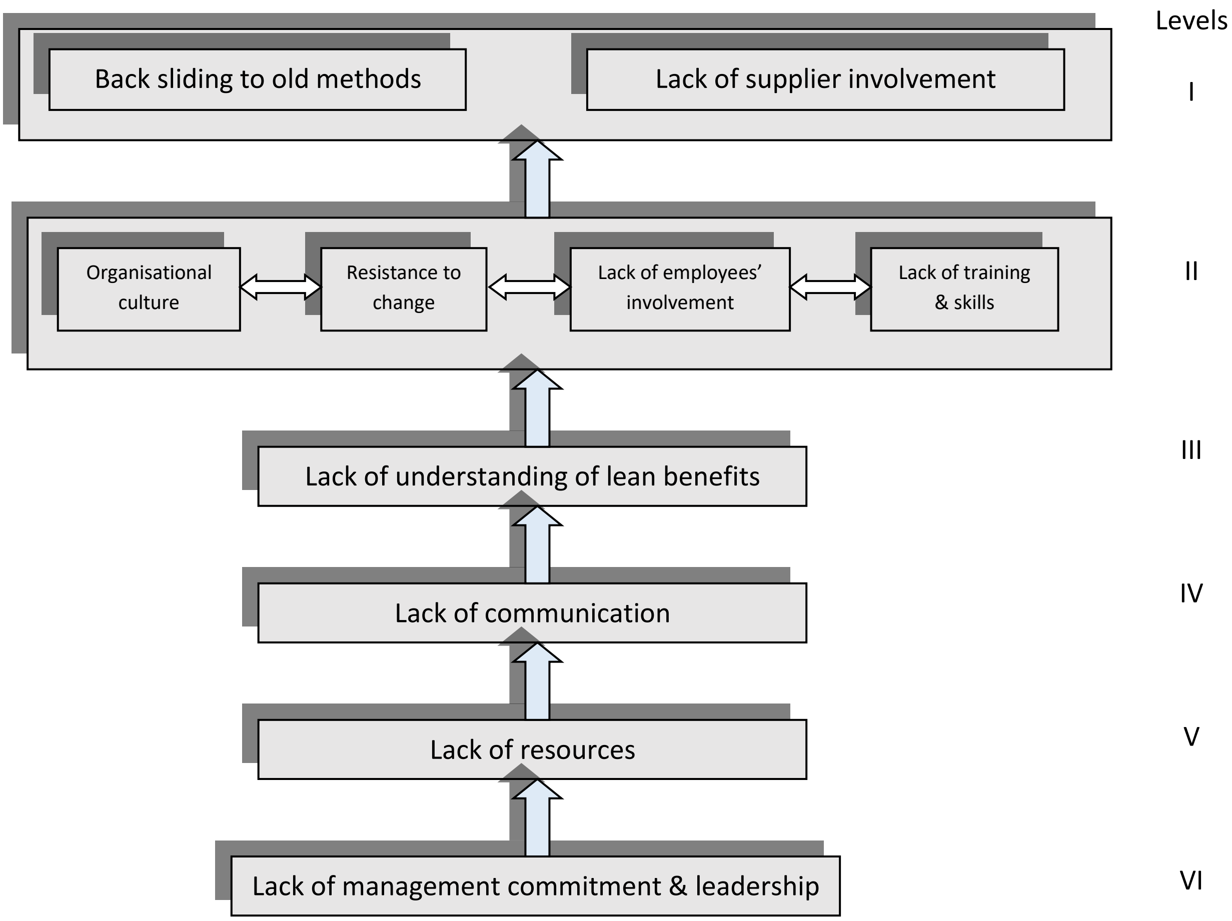

Figure 6. 11 ISM based model for LIBs

6.9.1 MICMAC analysis

Using the MICMAC analysis, the barriers were classified into four groups on the basis of their driving and dependence powers. These categories are named as autonomous, dependent, driver or independent, and linkage barriers. The dependence and driving power of barriers were calculated from the final RM and shown in Table 6.16. The driver-dependence diagram for MICMAC analysis was drawn and shown in Figure 6.12.

Table 6. 16 Dependence and driving power matrix

	B1	B2	B3	B4	B5	B6	B7	B8	B9	B10	Driving Power
B1	1	1	1	1	1	1	1	1	1	1	10
B2	0	1	0	0	1	1*	1*	0	1	0	5
B3	1	0	1	0	1	1	1*	1	1	1*	8
B4	0	0	1*	1	0	0	1	0	0	0	3
B5	0	1*	1*	0	1	1	1	1	1	0	7
B6	0	1	1	0	1	1	1	0	1	0	6
B7	1*	1	1	0	1	1	1	1	1*	1*	9
B8	1	1*	0	0	1	1*	1*	1	1	1*	8
B9	0	0	0	0	0	0	0	0	1	0	1
B10	0	0	0	0	0	0	0	0	0	1	1
Dependence Power	4	6	6	2	7	7	8	5	8	5	58

It was noted that a lack of management commitment and leadership has high driving power which signifies that the level of management commitment affects the other LIBs in SMEs. It was also noted that ‘lack of training and skills’ has high driving as well as high dependence power. The ISM model also suggests that management commitment, communication level, and availability of resources affect training and skills which in turn affect other barriers viz. ‘backsliding to old methods,’ ‘employee involvement,’ ‘organisational culture’ and ‘resistance to change.’ Similarly, ‘lack of communication,’ ‘resistance to change’ and employee involvement’ are linkage barriers but with relatively lesser driving and driven power. Backsliding to old methods has high dependence which suggests that other barriers may affect this while it does not affect other barriers.

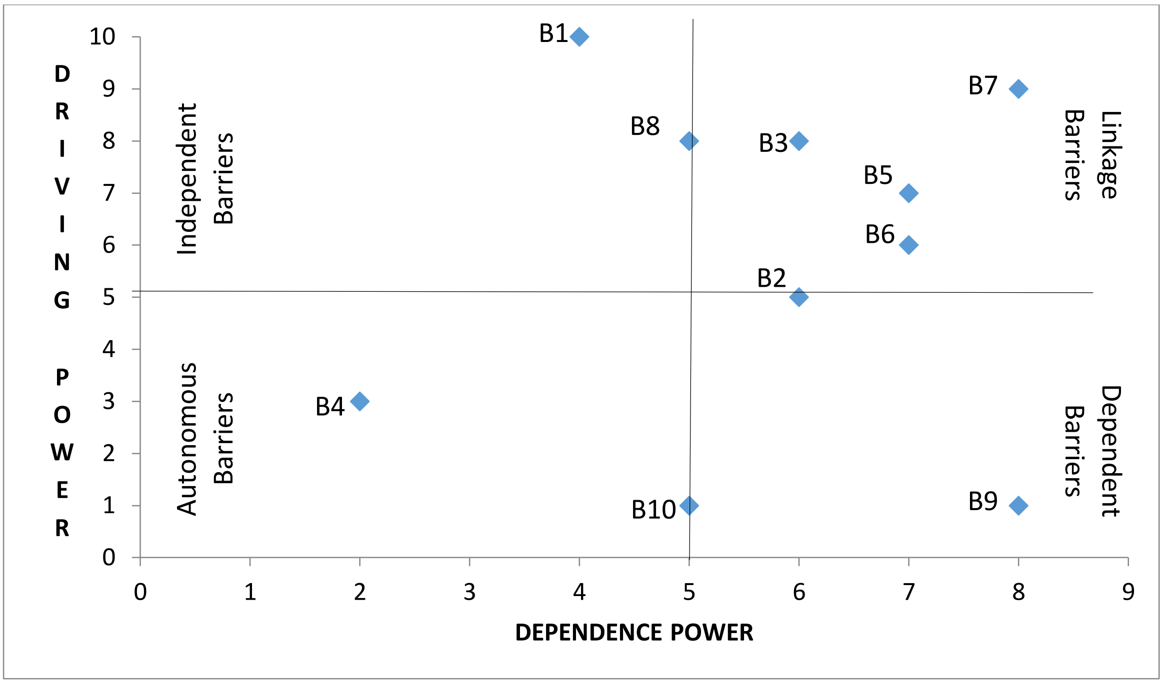

Figure 6. 12 Driver-Dependence diagram for MICMAC analysis

6.10 Conclusion

Four case studies have been presented in this chapter. The results of the cases support the findings of the survey. It may be concluded from the survey and case findings that the Indian SMEs significantly adopted most of the lean practices but two lean practices namely supplier involvement and visual management are missing in the case companies. After the assessment of lean practices, the barriers to implement lean (LIBs) in SMEs were identified and modelled using ISM.

The results suggested that 'lack of management commitment and leadership' is of utmost importance as it lies at the lowest level. This finding is consistent with other studies like Netland (2015); Zhang *et al.* (2017). Being the most crucial barrier, 'lack of management commitment and leadership' also impacts on other LIBs. Thus, for successful lean implementation in SMEs, a proper commitment of management and owner is mandatory, and training should be provided to the managers to improve their leadership and other managerial skills. In addition to this, 'lack of resources, communication, and understanding of lean benefits' also the major barriers in lean adoptions and they have an impact on other barriers. These barriers have more importance in the context of SMEs because of the characteristics of this sector, while these are largely ignored by most of the scholars concentrating on large enterprises. Achanga et al. (2006) also stated that resource inadequacy is the major hindrance to implement lean in SMEs. The model helps academicians in improving understandings regarding LIBs with their comparative importance and the interdependencies among these barriers.

From the practitioner's perspective, the finding of this research helps in understanding the LIBs and their interdependence. On the basis of the model, one can prioritize the barriers and focus on them accordingly. Before starting the lean implementation, the firm must ensure that the management is committed and have the leadership skills to pursue the employees for lean. Further, lack of resource is one of the major hindrances for lean implementation in SMEs, but it is suggested that SMEs can start lean adoption with small funding (Bhasin 2012) or may think for mobilizing additional resources to gain the immense benefits of lean implementation. Like many other management initiatives, lean also requires effective communication between all levels of the organisation. The improved communication would lead to a greater understanding of the probable benefits among the stakeholders, employee involvement, training and skills, organisational culture and supplier involvement. According to Wong *et al.* (2009), the major problem in lean implementation is the propensity to revert to traditional practices when difficulties are encountered. Hence, proper supervision and motivation are required during the transformation phase. Apart from these internal issues, it is necessary to extend the lean implementation to the supply chain partners.

Chapter 7

Development of lean implementation framework in SMEs

7.1 Introduction

Large firms typically have comprehensive business models, a long-term orientation, enjoy economies of scale, high risk-taking abilities, and high levels of organisational structure. Most of the existing frameworks in the literature on lean implementation have evolved based on such large-firm characteristics. Conversely to LEs, SMEs have a short-term orientation, simple organisational structures, a low risk - taking character, simple decision-making processes, resources constraints and flexible production systems. Therefore, the operational improvement frameworks for LEs may not be suitable for SMEs. For operational improvements in SMEs, an exclusive framework is required.

One of the objectives of this study is to develop the lean implementation framework for SMEs. On the basis of extant literature review and the findings of survey and case studies, a conceptual lean implementation framework is developed for SMEs. As discussed in chapter 2, some of the SME characteristic create a positive environment of lean adoption. On the other hand, there are some factors that resist the implementation of lean, that were discussed in the chapter 6 (Barriers to implement lean, LIBs). Therefore, a good framework should consist some lean practices and also consider the LIBs simultaneously.

The next section demonstrates the conceptual framework to adopt lean which consist of lean practices, performances and the barriers to implement lean in SMEs. Further, the lean implementation framework for SMEs is presented which include conceptual phase, planning phase, implementation phase and control phase. Finally, this chapter is concluded in the last section.

7.2 Development of lean implementation framework

Based on the findings of the survey from Chapter 4 & 5 and experience gained through case studies (Chapter 6), a framework for implementation of lean thinking for SMEs is proposed. Figure 7.1 gives the proposed conceptual lean framework.

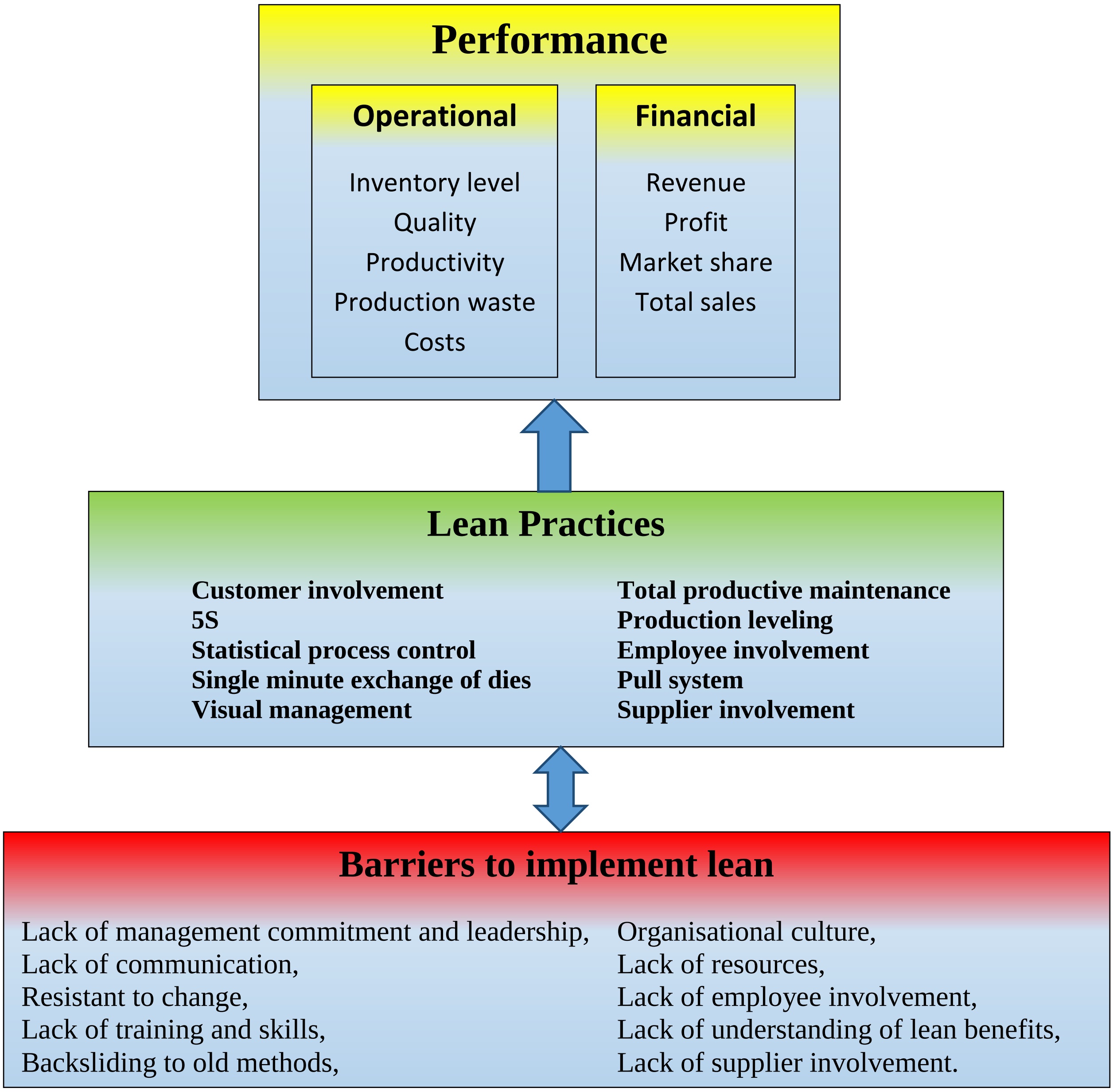

Figure 7. 1 Conceptual framework to adopt lean in SMEs

The framework consists three attributes i.e. barriers, practices and performances. The application of lean practices can improve the operational and financial measures. But in SMEs there are some factors which resist the adoption of lean practices, so these factors should also be included in the lean framework. Only 10% or less of organisations have successfully adopted lean practices (Bhasin and Burcher 2006). One possible reason for failure of many lean initiative is ignoring or improper dealing of the barriers to implement lean (Dora *et al.* 2013). Barriers decide success or failure of the lean journey. According to Achang et al. (2006), the barriers directly impact on the success of lean implementation in any organisation. Therefore, to focus on the determinant factors which influence the lean implementation, is very important.

LIBs were already identified through survey and case studies. For successful implementation of lean principles, the commitment of top management is vital (Achanga *et al.* 2006; Worley and Doolen 2006; Timans *et al.* 2012; Dora *et al.* 2015). It is a primary responsibility of management to educate and motivate the employees to support the adoption of lean at all levels. It is imperative that top managers are committed to a long-sight vision of performance and enhancement of the employees' involvement in improvement programmes (Panizzolo *et al.* 2012). Additionally, the establishment of participative organisational culture is also a crucial factor for successful lean implementation (Panizzolo *et al.* 2012; Zhou 2012; Dora *et al.* 2013). A long-term orientation, teamwork and excellent communication are also vital for a transformation to lean (Dora *et al.* 2015). Further, SMEs typically employ a workforce with relatively limited skills and often regard training as a luxury (Achanga *et al.* 2006; Mathur *et al.* 2012; Albliwi *et al.* 2014), while a lean transformation requires a high level of expertise and training. The engagement and empowerment of employees are also crucial in the lean drive (Hu *et al.* 2015). However, it was observed that SMEs often have poor financial arrangements which act as a major barrier in the adoption of lean (Achanga *et al.* 2006; Zhou 2012; Dora *et al.* 2013; Chaplin *et al.* 2016). Lean transformation also requires clear communication between all the partners in a value stream (Timans *et al.* 2012; Hu *et al.* 2015).

As per the survey findings, Indian SMEs are adopting eight lean practices out of ten practices (considered in this study). Whereas, in the framework all ten practices are included because the rest two practices (visual management and supplier involvement) are core practices of lean and Indian SMEs should also focus on these practices.

As the survey results (Chapter 5) revealed that the SMEs are adopting lean thinking in a partial or piecemeal manner due to two LIBs i.e. lack of financial resources and lack of expertise. Case studies (Chapter 6) also revealed the same. Hence, the whole lean transformation process should be split into small projects that a SME can handle. The step by step execution of these small projects can improve operational measures. These small projects consist implementation of a few lean practices. The lean implementation framework is presented in figure 7.2.

The lean implementation framework consists four phases i.e. conceptual phase, planning phase, implementation phase and control phase. As seen in figure 7.2, the first three phases (conceptual, planning and implementation) are sequential while the control phase run parallel to each phase.

7.2.1 **Conceptual phase**

It is inception phase of lean thinking in an organisation. This phase has four steps; building lean team, training of top executives, creating communication channels and defining lean assessment metrics. This phase starts with building of lean team. The team may have four-five members, two or three are from the top executives of the organisation and two or three are lean expert may be outside the organisation. Generally, in India, SMEs are hiring some consultants as lean experts. Once the team is built, the next step is to provide the lean training to the top executives of the organisation. This will improve their understanding and removes the barrier 'lack of management commitment and leadership', that was found most critical barriers in chapter 6.

Then next step is to create proper communication channels. Effective communication between all levels of organisational hierarchy as well as between internal and external stockholders is mandatory for any management initiatives including lean. It works as cement between bricks. A proper communication within the organisation and between its stakeholders is the key success factor for lean implementation.

The final step of this phase is to define the lean assessment metrics. It is argued that if the benefits of any new initiatives are clear to the stack holders, they become motivated towards the adoption of the initiative. Additionally, measurement of improvements also motivates the stakeholders (Bhasin 2012). Therefore, the assessment of lean is crucial to each level and assessment requires proper definitions of lean metrics.

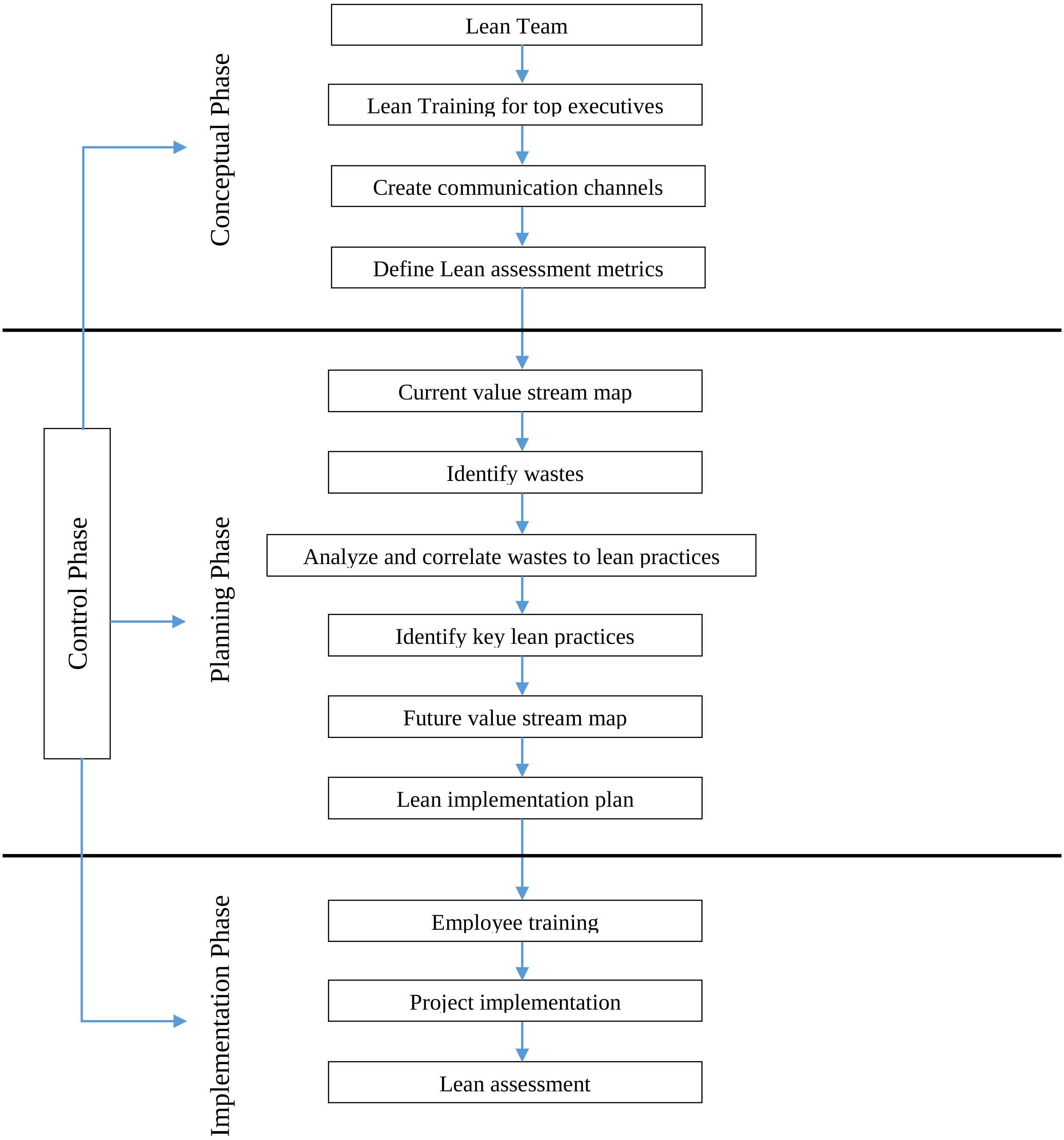

Figure 7. 2 Lean implementation framework for SMEs

7.2.2 **Planning phase**

This is warming-up or design phase which aims at developing an implementation plan. This phase has six steps: developing current value stream map, identifying waste, correlating identified wastes to lean practices, developing future value stream map and developing implementation plan.

The first step is to develop the current value stream map of the existing process. Value stream mapping (VSM) is widely used tool to identify the value adding and non-value adding activities in the process. Once the current value stream map is developed, the lean team can easily identify the wastes within the process. Using brainstorming, the team can rank the wastes according to their criticality; they can also use multi-criteria decision making approaches like analytic hierarchical process, analytic network process, fuzzy analytic hierarchical process, technique for order performance by similarity to ideal solution method (TOPSIS), etc.

The next step is to correlate the lean practices available with the identified wastes in the process. They can use quality function deployment (QFD) tool to check the association of wastes to lean practices. As the SMEs cannot focus on all the identified wastes at a time due to lack of resources skills and expertise. Therefore, they should focus on most crucial wastes (one or two) and the lean practices associated to these wastes should be implementation in the first project. After the completion of first project they can again repeat the same process. Therefore, project by project the SME will move toward perfection. Once the key lean practices are identified, the lean team can develop the future value stream map that will help in building the lean implementation plan.

7.2.3 **Implementation phase**

Once the lean implementation plan is developed one can easily implement the lean practices but as reported in the literature review that many lean implementation project failed due to the lack of employee involvement, training and skills and resistance of change. Therefore, to overcome these barrier employee training for lean practices and motivation before the implementation is mandatory. This training will not only demonstrate the way of adoption of lean practices but also clarify the benefits of lean adoption in SMEs that will motivate the employee for lean implementation in SMEs.

After training of employee, the SME is ready for lean implementation. Under the supervision of lean expert team, the SME can implement the lean practices that are shortlisted in planning phase. Then the next step is to assess the lean adoption in the organisation. It will be done using the lean assessment metrics decided in the conceptual phase.

7.2.4 Control phase

This phase runs throughout the project. The monitoring of the project should be done by the lean team throughout the project and some corrective action should be taken if there is a deflection between plan and execution.

7.3 Conclusion

In this chapter, a lean implementation framework for SMEs is developed, this was one of thr research objective of this study. Along with lean practices and performances, the lean implementation barriers (LIBs) were also considered. Therefore, this framework not only demonstrate the way of implementing lean practices in the organisations but also helps in managing the LIBs.

Chapter 8

Discussions and Conclusion

8.1 Introduction

This chapter outlines conclusion and discussions with the managerial and practical implications of the study. It also provides summary of the thesis. Finally, the chapter will conclude with the limitations of the study and the directions for future research.

Toyota developed the Toyota Production System (TPS) in Japan. This concept evolved into lean manufacturing (Krafcik, 1988) in the USA and then diffused to other developed economies. Although numerous studies have reported the significant benefits of lean adoption in large enterprises (Shah and Ward 2003; Shah and Ward 2007; Belekoukias et al. 2014; Bevilacqua et al. 2017), a lot of scepticism still remains regarding its impact in small and medium-sized enterprises (SMEs). The benefits of lean adoption need to be fully considered and evaluated in SMEs. Similarly, to lean research in general, lean adoption in SMEs has recently gained attention in developing countries such as India, where SMEs account for 45% of exports, 45% of the total manufacturing output and employment to over 80 million people (MSME 16).

A few lean implementation case studies in SMEs can be found in the literature (Kumar *et al.* 2006; Upadhye *et al.* 2010; Panizzolo *et al.* 2012; Arya and Jain 2014; Vinodh *et al.* 2014; Arya and Choudhary 2015; Gupta and Jain 2015) principally concentrating on the level of implementation and the development of presentational and analytical frameworks. However, the literature concerning the impact of lean adoption on operational performance in SMEs is limited. Thus, there was a strong need for further investigation into the relationship between lean implementation and performance measures in SMEs. Here, in this research, an attempt was made to fill the gap by first assessing the degree of adoption of lean practices in SMEs and, subsequently, analyzing the impact of lean practices on the operational & financial performance of SMEs. A survey of 425 Indian SMEs was carried out, and the data was analyzed using a Structural Equation Modelling (SEM) approach. It was found that a limited number of lean practices are being implemented by Indian SMEs but this partial lean implementation is having a positive impact on operational and financial performance. The survey results are validated through case studies and then, finally a lean implementation framework was developed for SMEs.

Next section presents the summary of the present study and this is followed by the discussions and conclusions of the research. Then last section discusses the limitation of the current study and scope and directions for future research.

8.2 Summary of the study

The study started with a literature review. By reviewing a plethora of literature, research gaps were identified. Most of the prior studies was conducted in developed economies whereas developing economies were largely ignored by the academicians and researchers. A very few studies regarding lean thinking concentrated on the small and medium enterprises. Majority of the frameworks for lean implementation were concentrating on the large enterprises. Due to the characteristic difference of SMEs to large enterprises, these frameworks are not suitable for SMEs. Therefore, the study aimed at exploring the status, impact and issue of lean thinking in SMEs in developing economy (India). The objectives of the study were to

- To explore lean implementation issues in SMEs
- To establish the relationship between lean practices and performance improvement in SMEs.
- To develop a lean implementation framework for SMEs.

After the comprehensive literature review, research hypotheses were developed to address the above research objectives and further to test these hypotheses a survey instrument was constructed. The questionnaire was organized into three sections: the first section included the demographic information, the second included the questions related to the implementation of lean practices, and the third section was dedicated to the operational and financial performance of the SMEs. Content validity of the questionnaire was confirmed by pre-testing it on an expert team. A pilot testing was performed with thirty SMEs, randomly selected from the population. Each of the thirty responses were received from personal visits, and three questions were modified as per their feedback. The survey was carried out in SMEs covering fifteen states: Andhra Pradesh, Bihar, Delhi, Goa, Gujarat, Haryana, Jharkhand, Madhya Pradesh, Maharashtra, Punjab, Rajasthan, Tamil Nadu, Uttar Pradesh, Uttrakhand and West Bengal in India. The survey was conducted from June 2017 to October 2017. The survey companies were randomly identified from the database of the Confederation of Indian Industries (CII).

From the survey result the significant reasons of lean implementation in SMEs, critical success factors of lean implementation in SMEs and barriers to implement lean in SMEs were identified. Further, structural equation modelling approach is used to test the impact of lean thinking on the operational and financial performance of SMEs. The results confirmed the perception that rather than a full lean concept, SMEs are adopting lean in a partial manner, i.e., implementing a limited number of practices. The findings supported the statement 'the application of lean practices is positively associated with the operational performance of SMEs.' A major finding of the study is the mediating role of the operational measures in the relationship between the partial lean adoption and the economic performance. It implies that lean adoption not only improves that operational measures but also positively affects the financial measures.

Further four case studies were carried out. Multiple cases lead to a better understanding of lean adoption in Indian SMEs and will help in interpretation of proposition formulated in the study. The case findings also support the survey results; this validates the results. After the assessment of case studies, the barriers to implement lean (LIBs) in SMEs were identified and modelled using ISM approach.

Lastly, a lean implementation framework for SMEs was developed. Along with lean practices and performances, the framework also helps in dealing with lean implementation barriers (LIBs). Therefore, this framework not only demonstrate the way of implementing lean practices in the organisations but also helps in managing the LIBs. Hence, all the research objectives were achieved and limitations and directions for future research were proposed.

8.3 Discussions and implications

Most of the existing studies are mainly concentrating the large enterprises, but their findings may not be consistent with SMEs due to the characteristical difference between the two. As compared to large enterprise, SMEs have limited resources, less expertise, and fewer skills; thus, with these constraints, it is not possible for SMEs to adopt full lean in their organization and in supply chain. SMEs especially working in developing economy are implementing lean in a partial manner or with a piecemeal approach.

Prior literature advocates the adoption of lean thinking in an integrated way for achieving the operational and financial benefits. This is true for the large enterprises where the resources and skills are not the constraints, while SMEs adopt the lean in a partial manner or with a piecemeal approach. None of the existing research has empirically tested the impact of this partial adoption of lean in SMEs. This study provides a clear picture of the relationships among partial lean adoption, operational performance and economic performance in the context of SMEs. The evidence from this study suggests that even in a partial manner, lean is capable of improving the operational and financial performance of the organization. The findings also confirm the mediating role of the operational performance in deriving the economic performance associated with lean adoption.

This study confirms the perception that rather than a full lean concept, SMEs are adopting lean in a partial manner, i.e., implementing a limited number of practices; eight (out of ten) lean practices are in the core concept of lean thinking for SMEs. Full implementation of lean requires a lot of investment, whereas generally SMEs do not have sufficient financial support. Additionally, lack of skills and expertise also restricts SMEs to full lean implementation in an integral manner. This finding is consistent with Filho *et al.* (2016) which empirically tested the hypothesis that SMEs are implementing a limited number of lean practices in a fragmented way. Findings of the study also support the argument that when a new sector adopts lean, it will adapt to support the adoption and implementation of the new practices. Hence, thr study validates the dynamic nature of lean (Holweg *et al.* 2007).

One of the objectives of the current research was to assess the impact of lean implementation on the operational performance of SMEs. From the results, it may be concluded that the application of lean practices is positively associated with the operational performance of SMEs. Hence it can be concluded that even in the partial manner the impact of lean on the operational performance is positive and significant. The results are in line with the prior studies (Filho *et al.* 2016; Panwar *et al.* 2018). It reveals that the lean implementation can helps SMEs with inventory reduction, productivity improvement, wastes elimination, and cutting down costs. Apart from that this study also confirms that the adoption of partial lean adoption also has a positive impact on the economic performance. This result is consistent with Fullerton and Wempe (2009) and Hofer *et al.* (2012). The finding further implies that the partial lean adoption in SMEs supports the profitability of the organisation.

A major finding of the study is the mediating role of the operational measures in the relationship between the partial lean adoption and the economic performance. It implies that lean adoption not only improves that operational measures but also positively affects the financial measures. The operational measures like inventory reduction, productivity improvement, wastes elimination, and cutting down costs, directly affect the profitability.

Further the barriers to implement lean (LIBs) in SMEs were identified and modelled using ISM. The results suggested that 'lack of management commitment and leadership' is of utmost importance as it lies at the lowest level. This finding is consistent with other studies like Netland (2015); Zhang *et al.* (2017). Being the most crucial barrier, 'lack of management commitment and leadership' also impacts on other LIBs. Thus, for successful lean implementation in SMEs, a proper commitment of management and owner is mandatory, and training should be provided to the managers to improve their leadership and other managerial skills. In addition to this, 'lack of resources, communication, and understanding of lean benefits' also the major barriers in lean adoptions and they have an impact on other barriers. These barriers have more importance in the context of SMEs because of the characteristics of this sector, while these are largely ignored by most of the scholars concentrating on large enterprises. Achanga et al. (2006) also stated that resource inadequacy is the major hindrance to implement lean in SMEs. The model helps academicians in improving understandings regarding LIBs with their comparative importance and the interdependencies among these barriers.

From the practitioner's perspective, the finding of this research helps in understanding the LIBs and their interdependence. On the basis of thr model, one can prioritize the barriers and focus on them accordingly. Before starting the lean implementation, the firm must ensure that the management is committed and have the leadership skills to pursue the employees for lean. Further, lack of resource is one of the major hindrances for lean implementation in

SMEs, but it is suggested that SMEs can start lean adoption with small funding (Bhasin 2012) or may think for mobilizing additional resources to gain the immense benefits of lean implementation. Like many other management initiatives, lean also requires effective communication between all levels of the organisation. The improved communication would lead to a greater understanding of the probable benefits among the stakeholders, employee involvement, training and skills, organisational culture and supplier involvement. According to Wong *et al.* (2009), the major problem in lean implementation is the propensity to revert to traditional practices when difficulties are encountered. Hence, proper supervision and motivation are required during the transformation phase. Apart from these internal issues, it is necessary to extend the lean implementation to the supply chain partners.

Moreover, a lean implementation framework was developed which can help the practitioner in systematically implementing the lean thinking principle in the SMEs. This framework not only demonstrate the way of implementing lean practices but also includes how to handle with barriers to implement lean thinking. Therefore, it will reduce the probability of failure in lean implementation projects.

8.4 Limitations and scope for future research

However, this study contributed in the existing knowledge regarding lean thinking and assessed the impact of lean thinking on operational and financial performance and proposed a lean implantation framework for SME. But the study should also be viewed with some limitations and caution is suggested when interpreting the results. Although the sample size was adequate and representative it is limited to an Indian context. Further research is required in a more diverse context to confirm the generalization of the results. It is worthwhile to extend the study to different SME sectors.

The impact of lean implementation is not only limited to operational and financial performance; it also enhances the social and environmental performance (Yadav *et al.*, 2018). Therefore, the empirical study may be extended to verify the impact of lean thinking on sustainable performance.

Current study explored performance improvement measures through implementation of lean in SMEs; however, literature to measure degree of leanness of SMEs is scarce. Furthermore, SMEs are relatively new customers of lean thinking. Hence, on the shop floor, the traditional key performance indicators exist which are more likely related to capacity utilization, output and quality control. Whereas, in a lean environment, a new group of key performance indicators are needed, which not only target the above goals but also provide support in achieving other objectives of implementing lean. For example, level of wastes, employees' suggestions, level of inventories, and amount of shortages or backorders. Therefore, a potential area for further research would be to develop analytical models to quantify the leanness of SMEs based on key characteristics of a SMEs.

Although the 'supplier involvement' and 'visual management' are crucial for any lean project but this study is not able to explore the more on these practices. Supplier involvement should be vital for SMEs to maintain quality and for cost effective procurement in SMEs. Therefore, these issue needs further research. A longitudinal study is required to assess the relationship of development, involvement and integration of suppliers with performance benefits for SMEs.

Majority of the activities in SMEs are interdependent. Similarly, the impacts of improvements are also interdependent. It is therefore quite challenging to measure the impact of a single lean practice on an independent activity. Further research is needed to scientifically explore the impact of lean adoption in SMEs to find out accurately which lean practice/tool or technique has impacted in what improvement.

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Appendix-1

Lean assessment questionnaire

Name (optional): ……………………………………………………

Position: [ ] Junior Management [ ] Middle Management [ ] Senior Management [ ] Owner/Promoter/CEO

Company's Name & Address: ………………………………………………………………………

…………………………………………………………………………………………………

1. Type of company: [ ] Automobile [ ] Electrical & Electronics [ ] Machinery [ ] Process any other ………………………………………..
2. Investment in plant and machinery:
   [ ] up to Rs. 25Lakh [ ] above Rs. 25 Lakh & upto Rs. 5 Crore
   [ ] above Rs. 5 Crore & upto Rs. 10 Crore [ ] above Rs. 10 Crore
3. Type of organisation
   [ ] Proprietorship [ ] Partnership [ ] Private Limited Company
4. Type of customers you have [ ] Other industry [ ] End consumer
5. Production type [ ] make to order [ ] make to stock
   [ ] engineer to order[ ] assemble to order [ ] other……………………………….
6. How many employees are there in your organisation (Permanent + Temporary): ………………
   Skilled ………………….. Semiskilled ………………… Unskilled ………
7. Are you familiar with lean manufacturing? :
   [ ] Yes [ ] No
8. Do you think lean manufacturing is useful for SMEs?
   [ ] Yes [ ] No
9. Has your organisation implemented lean or productivity improvement tools?
   [ ] Yes [ ] No

10.If you have implemented lean manufacturing, kindly specify reasons on five point Likert scale (Consider 1= least important and 7 = most important)

S.No.	Reasons	1	2	3	4	5	6	7
1	To eliminate production wastes							
2	To decrease production costs							
3	To improve quality							
4	To increase productivity							
5	To increase demand management and efficiency							
6	To increase customer satisfaction							
7	Any other ………………………………………………………………………………							

11.Please indicate the extent of implementation of Lean practices (Consider 1= low implementation, 2= little implementation, 3= some implementation, 4= extensive implementation and 5= complete implementation)

		1	**2**	**3**	**4**	**5**	**6**	**7**
CI1	We are in close contact with our customer							
CI2	Customers give feedback on quality and delivery performance							
CI3	Customers are actively involved in current and future product offerings							
CI4	Customers frequently share the demand information							
EI1	Shop floor employees are actively involved in problem solving							
EI2	Shop floor employees are actively involved in process improvements							
EI3	Shop floor employees regularly give suggestions for product improvement							
EI4	Shop floor employees undergo cross functional training							
SI1	We give our suppliers feedback on quality and delivery performance							
SI2	We strive to establish long term relationship with our suppliers							
SI3	Our key suppliers are located in close proximity to our plant							
SI4	We take active steps to reduce the number of suppliers in each							

	category							
PS1	Production is pulled by shipment of finished goods.							
PS2	Production at workstations is pulled by the demand of the next station							
PS3	We use Kanban, squares or containers of signals for production control							
PS4	We use pull system to control the production rather than schedule prepared in advance							
5S1	Only the materials which are actually needed are present in the work area.							
5S2	Only tools and hand tools which are needed are present in the work area.							
5S3	Locations for all production materials are clearly marked out and the materials are stored in the correct locations. Areas for WIP (Work In Process parts) are clearly marked.							
5S4	Work areas, storage areas, aisles machines, tools, equipment and offices are clean/neat and free of safety hazards.							
5S5	Regularly schedule housekeeping tours and periodic self assessments (5S audits) are conducted.							
TPM1	We maintain all our equipment regularly.							
TPM2	We maintain records of all equipment maintenance activities.							
TPM3	We ensure that machines are in high state of readiness for production at all the time.							
TPM4	Operators are trained to maintain their own machines.							
SPC1	Charts showing defects are used as tools on the shop floor							
SPC2	We use diagrams like cause & effects (fishbone) to identify causes of quality problems							
SPC3	We conduct process capability studies before product launch							
SPC4	Extensive use of statistical techniques to reduce process variance							
SMED1	We are working to lower setup time in our plant							
SMED2	We have low setup times of equipment in our plant							
SMED3	Operators perform their own machines setups.							
SMED4	Operators are trained on machine setup activities.							

SMED5	We emphasize to put all tools in feasible area to the operator.							
VM1	Equipment are identified with signages							
VM2	Process parameters are displayed on shop-floor							
VM3	Manufacturing performance is displayed on shop floor							
PL1	We produce more than one product model from day to day (mixed model production)							
PL2	We emphasize on a more accurate forecast to reduce variability in production.							
PL3	Each product is produced in a relatively fixed quantity per production period.							
PL4	We emphasize to equate workloads in each production process.							
PL5	We produce by repeating the same combination of products from day to day.							
PL6	We always have some quantity of every product model to response to variation in customer demand.							

12. Performance measures (Consider 1= least important and 7 = most important)

	Performance measures	**1**	**2**	**3**	**4**	**5**	**6**	**7**
OP1	We have low Inventory level (Raw material, WIP and Finished goods)							
OP2	The Quality of products is satisfactory.							
OP3	Our Productivity is high.							
OP4	We have low Production wastes.							
OP5	Our Production Costs are less.							
FP1	Organisation enjoys high Profit							
FP2	Firm has high Revenue							
FP3	Market share of the firm is significant.							
FP4	Total sales of the organisation are high.							
SP1	Work routine of the employees good							
SP2	Employee empowerment							

SP3	Employees are satisfied with Working environment							
SP4	Employees are working as in Teams							
SP5	Employees do not leave the company frequently							
EP1	Energy/power saving is significant							
EP2	Industrial Wastes are very less							
EP3	Pollution is under control							

13. Barriers in lean implementation in SMEs (Consider 1= least important and 7 = most important)

	Barriers	**1**	**2**	**3**	**4**	**5**	**6**	**7**
1	Lack of management commitment and leadership							
2	Organisational culture (which cover trust, hierarchy, working environment, and fellow-feeling)							
3	Lack of communication within the organisation							
4	Lack of resources (finance and human)							
5	Resistance to change							
6	Lack of Employee involvement							
7	Lack of training and skills							
8	Lack of understanding lean benefits (measuring benefits)							
9	Backsliding to old methods (habit of reverting to traditional practices)							
10	Lack of supplier involvement							
11	Any other………………………………………………							

International Journal Publications:

1. Yadav, V., Jain, R., Mittal, M. L., Panwar, A., & Lyons, A. (2019). The impact of lean practices on the operational performance of SMEs in India. *Industrial Management & Data Systems* 119 (2), 317-330. (SCI impact factor 2.948)
2. Yadav, V., Jain, R., Mittal, M. L., Panwar, A., & Lyons, A. C. (2019). The propagation of Lean thinking in SMEs. *Production Planning and Control*. (SCI impact factor 2.330)
3. Yadav, V., Jain, R., Mittal, M. L., Panwar, A., & Sharma, M. K. (2019). An appraisal on barriers to implement lean in SMEs. *Journal of Manufacturing Technology Management* 30 (1) pp. 195-212. (SCI impact factor-2.194)
4. Yadav, V., Khandelwal, G., Jain, R., & Mittal, M. L. (2019). Development of leanness index for SMEs. *International Journal of Lean Six Sigma* 10(1), 397-410. (Scopus index)
5. Yadav, V., Jain, R., Mittal, M. L., (2019). Effect of lean thinking on financial performance of SMEs, *International Journal of Production Economics* (Communicated).
6. Yadav, V., Jain, R., Mittal, M. L., (2018). A lean implementation framework for small and medium-sized enterprises. (in pipeline)

International/National Conferences

1. Yadav, V., Mittal, M. L &. Jain, R., (2017) Measuring Sustainability Achieved by Lean Efforts in SMEs, published in the proceedings of International conference on Development, Sustainability and Happiness, organized by Jaipuria Institute of Management, Jaipur, India.
2. Yadav, V., & Jain, R., (2016) Lean Manufacturing within Indian SMEs, published in the proceedings of International conference on Emerging Trends in Mechanical Engineering organized by ICFAI Group, Hyderabad, India.

Brief Bio-data of the Author

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