INVESTIGATION ON LEAN PRACTICES IN MANUFACTURING MICRO, SMALL AND MEDIUM ENTERPRISES AND THEIR EFFECT ON SUSTAINABILITY PERFORMANCE

A THESIS

Submitted to the University of Calicut

By

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DECLARATION

I hereby declare that this thesis entitled 'INVESTIGATION ON LEAN PRACTICES IN MANUFACTURING MICRO, SMALL AND MEDIUM ENTERPRISES AND THEIR EFFECT ON SUSTAINABILITY PERFORMANCE' submitted to the University of Calicut, for the award of Degree of Doctor of Philosophy under the Faculty of Engineering is an independent work done by me under the supervision of Dr. Shalij. P.R, Associate Professor, Department of Production Engineering, Government Engineering College, Thrissur, University of Calicut.

I also declare that this thesis contains no material which has been accepted for the award of any degree or diploma of any University or Institution and to the best of my knowledge and belief, it contains no material previously published by any other person, except where due references are made in the text of the thesis.

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This is to certify that the work reported in this thesis entitled 'INVESTIGATION ON LEAN PRACTICES IN MANUFACTURING MICRO, SMALL AND MEDIUM ENTERPRISES AND THEIR EFFECT ON SUSTAINABILITY PERFORMANCE' that is being submitted by Mr. SAJAN. M.P for the award of the Degree of Doctor of Philosophy, to the University of Calicut, is based on the bonafide research work carried out by him under my supervision and guidance in the Department of Mechanical Engineering, Government Engineering College, Thrissur, University of Calicut. The results embodied in this thesis have not been included in any other thesis submitted previously for the award of any degree or diploma of any other University or Institution.

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ABSTRACT

The impact of Lean Manufacturing (LM) on improving the performance of business houses has been recognised by the industrial organisations and policymakers. At the same time, the concept of sustainability is becoming a necessity in the manufacturing industries even without the external influences. Manufacturing firms are trying to improve their sustainability performances to meet the expectations of their multiple stakeholders.

Nowadays, integration of lean manufacturing and sustainability has been getting great attention and has generated keen interests among operations management researchers. Micro, Small and Medium Enterprises (MSMEs) have started implementing various manufacturing paradigms adopted by the large sized industries for their sustainable development. The adoption of lean manufacturing practices (LMPs) in MSMEs is lagging behind the large-scale industries, due to several reasons. The availability of resources is limited for MSMEs. This situation has forced them to operate with the limited available resources, and may even struggle to attain the environmental and social requirements. To overcome this shortcoming, MSMEs need a special attention.

Several authors have studied the linkage between lean and sustainability. These prior researchers in this particular area have concentrated primarily on large-scale industries. No intensive efforts have been so far undertaken to investigate the outcome of LMPs on sustainability performances of MSMEs. This research presents a study on the effect of LMPs in Indian firms and their effect on sustainability performances categorised into economic, environmental and social performances. The study also identified the interrelationship between the three categories of sustainability performances. Moreover, the 16 broader scope of areas of linkage between lean and sustainability beyond the general scopes as a waste reduction and environmental management are also recognised. Differences among the firms categorised based on the manufacturing sector, manufacturing process, production system and level of investment in areas of linkages between LMPs and sustainability were also investigated.

This study adopts a conceptual framework and a set of hypotheses based on an extensive literature review. Empirical data were collected by surveying 252 manufacturing firms and analysed by the Structural Equation Modeling (SEM) to derive the relationship between lean and sustainability. Exploratory factor analysis (EFA) was used for data reduction and for identifying the factor structure. A confirmatory factor analysis (CFA) was used to study the structural relationship between the LMPs and performance variables.

This study summarises the positive effects of LMPs towards the sustainability performance. The positive effects of environmental sustainability on economic and social sustainability performances and an insignificant effect of economic sustainability on social sustainability are also evident from the study. The novelty of the work lies in analysing how the lean practices influence sustainability performances and verifying the association between these performances in Indian manufacturing MSMEs. Detailed case studies were conducted to confirm the major findings from the statistical tests. The results of the study have provided a solid basis for adopting LMPS as a powerful tool to achieve sustainability performance in MSMEs.

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Thrissur Sajan. M.P
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LIST OF ABBREVATIONS

3BL	Triple Bottom Line
ANOVA	Analysis of Variance
ASMEs	Association of Small And Medium Enterprises
AVE	Average Variance Extracted
BRIC	Brazil, Russia, India and China
CFA	Confirmatory Factor Analysis
CFI	Comparative Fit Index
CR	Construct Reliability
CSF	Critical Success Factor
DIC	District Industries Centre
EFA	Exploratory Factor Analysis
EPA	Environmental Protection Agency
FPS	Ford Production System
GFI	Goodness of Fit Index
HRM	Human Resource Management
IFI	Incremental Fit Index
ISO	International Organisation for Standardisation
JIT	Just In Time
KMO	Kaiser-Meyer- Olkin
LMP	Lean Manufacturing Practice
MIIT	The Ministry of Industry and Information Technology
MLE	Maximum Likelihood Estimation
MRP	Material Requirement Planning
MSME	Micro, Small and Medium Enterprise
MSMED	Micro, Small and Medium Enterprise Development
MSV:	Maximum Shared Variance
NFI	Normed Fit Index
OHSAS	Occupational Health and Safety Assessment Series
PAF	Principal Axis Factoring

PCA	Principal Component Analysis
RMSEA	Root Mean Square Error of Approximation
SDWT	Self Directed Work Teams
SEM	Structural Equation Modeling
SGPS	Small Group Problem Solving
SMED	Single Minute Exchange of Die
SMM	Small And Medium Manufacturer
SOP	Standard Operating Procedure
SPSS	Statistical Package for Social Science
SRMR	Root Mean Square Residual
TLI	Tucker-Lewis Index
TMC	Toyota Motor Company
TPS	Toyota Production System’
TQM	Total Quality Management
UN	United Nations
VOC	Volatile Organic Compound
WCED	World Commission on Environment and Development
WIP	Work In Progress
WTO	World Trade Organization

CHAPTER 1
INTRODUCTION

1.1 INTRODUCTION

Lean Manufacturing (LM) is recognised as one of the most important manufacturing philosophy that facilitates the companies to compete and sustain in the current dynamic and competitive business world (Filho and Barco, 2015). LM originated in Japan and quickly spread to the USA, Europe as well as in most of the developed and developing countries (Pavnaskar et al., 2003). In the beginning, LM was mainly accepted in the automobile sector. In continuation to this, the implementation of various Lean manufacturing Practices (LMPs) have been causing a profound impact on the majority and wide range of sectors irrespective of the size of the firm. This list of sectors includes process industries, textile, hi-tech industries, aviation/aerospace, healthcare, and many others (Abdulmalek and Rajgopal, 2006; Wang, 2008; Ehret and Cooke, 2010; Kumar et al., 2015; Henrique et al., 2016). LM has also been applied in conjunction with other management approaches, such as Green Manufacturing (GM), Agile Manufacturing (AM) and Sustainable Manufacturing (SM) (Verrier et al., 2014; Putnik, 2012; Cabral et al., 2012).

Nowadays, manufacturing firms worldwide are set to confront their sustainability performances to satisfy their multiple stakeholders (Ganapathy et al., 2014). Stakeholder theory proposes that the “business entity should be used as a means for coordinating stakeholder interests rather than simply maximising shareholder profit” (Freeman, 1984). The stakeholders and the manifestation of their interest drive firms to adopt sustainable strategies. During recent times, sustainability has emerged as a new competitive criterion and becomes the primary objective of most forward-thinking organisations (Wang et al., 2015). Thus, sustainability performance improvement of the industrial processes has become a business imperative (Cherrafi et al., 2016). Sustainability focuses on the ‘triple bottom line’ (3BL) of ‘people, profit and planet’ (Elkington, 1997; Mitra and Datta, 2014) which considers the social and environmental values of business assessments along with their economic significance.

Micro, small and medium enterprises (MSMEs) frequently known as Small and medium enterprises (SMEs) are playing a crucial role in formulating the economies of most countries in the world (MSME, 2012; Bhamu and Sangwan, 2014) In literature, the terms MSMEs and SMEs are interchangeably used. The MSMEs are acting as the engine of the economic growth and providing social stability by generating the direct and indirect employment opportunities (Hu et al., 2015; Wang, 2016). In most of the developed and developing countries, a major share of the manufacturing output is from the contributions of MSMEs. But the MSMEs all over the world are facing a lot of challenges and problems in doing the business compared to large firms. Ensuring the sustainable growth and performance of the MSMEs are necessities of the current manufacturing world.

A conflict of interest exists in SMEs, between the entities of 3BL, as the focus is more on profit compared to people and the planet (Wong and Wong, 2014). Consequently, this conflict makes the decisions on balancing the operational or financial performances with sustainability performance of MSMEs too complicated. SMEs have started implementation of the various manufacturing paradigms adopted by the large sized industries for their sustainable development (Singh et al., 2008; Panizzolo et al., 2012). The researchers also have studied and recommended solutions to the problems and difficulties faced by MSMEs. These changes have helped MSMEs in emerging as the engine of economic growth (Singh et al., 2008; Hu et al., 2015; Wang, 2016) and as the principal instrument for promoting sustainable development of economies (Klewitz and Hansen, 2014).

Interestingly, LMPs are now increasingly being recognised by the MSMEs in different countries, and this approach proved as a successful operational model in developing economies, as well as in some large Indian companies (Panizzolo et al., 2012; Bhamu and Sangwan, 2014). The Government of India has instituted the ‘lean manufacturing competitiveness scheme’ for MSMEs to assist them in reducing waste, increasing the productivity, and imbibing a locale of continuous improvement (Thanki and Thakkar, 2014).

The linkage between lean and sustainability has been studied by several authors (Rothenberg et al., 2001; Azevedo et al., 2012; King and Lenox, 2001; Kainuma and Tawara, 2006; Mollenkopf et al., 2010; Xavier Alves and Murta Alves, 2015; Piercy and Rich, 2015). These researches have concentrated primarily on large-scale industries such as automotive, pharmaceutical and fast moving consumer goods (FMCG) industries where the impacts of the linkage are more significant than MSMEs (Bhasin, 2012; Shaw and Ward, 2003; Piercy and Rich, 2015). Moreover, large organisations have greater awareness and availability of a lean manufacturing system while MSMEs usually lag behind (Pannizzolo et al., 2012; Upadhye et al., 2013). The MSMEs also have constraints for mobilising the resources, which in turn, will force them to operate with limited resources, and may even ignore the environmental and social requirements (Theyal and Hofmann, 2012). The negative impact of all these factors results in lack of attention in the business, and the role of strategies for sustainable development gets sidelined. To overcome this barrier, MSMEs need a special attention in their sustainable development (Loucks et al., 2010).

The previous studies in MSMEs have examined LMPs effects on operational, financial and environmental performances independently (Filho et al., 2016; Bonavia and Marian, 2006; Upadhe et al., 2013; Rahman et al., 2010; Panizzolo et al., 2012; Khanchanapong et al., 2014; Zhou, 2012). None of these studies have investigated the effect of LMPs on different dimensions of sustainability performance in a single study. Also, these researchers have not focused on the relationship between LMPs and sustainability performance. Hence, the effect of LMPs on sustainability performances grouped into economic, environmental and social sustainability performances in MSMEs have been uncertain till this date.

Implementation of sustainable manufacturing practices has become a requirement, primarily due to the changes in laws and regulations in the new global business environment. The insistence from stakeholders has increased the pressure and responsibility of manufacturers in making sure the sustainable manufacturing practices are implemented (Martínez-Jurado and Moyano-Fuentes, 2014; Yusup et al., 2015).

This necessitates the integration of existing manufacturing practices such as LM with sustainable manufacturing (Hallstedt et al., 2013).

Such integration helps to establish continuity in improving the manufacturing operations, as well as increasing the level of competitiveness in a new global manufacturing environment (Schrettle et al., 2014). The novelty of this work lies in analysing how the lean practices influence sustainability performances and verifying the association between these performances in Indian manufacturing MSMEs.

1.2 RESEARCH PROBLEM

The research problem is formed from the aspiration and vital necessity to improve on the conventional lean performance model that have been espoused by most researchers so far. The existing lean performance models and studies concentrated on the effect of LMPs on operational, financial performances, mostly on a large scale industries. There are no such studies which focused on MSMEs to bring out the effect of LMPs on their sustainability performances. The interrelationships between the sustainability performance generated by the LMPs implementation in MSMEs are also unfamiliar. Similarly, limited studies have been reported in the areas of linkage between lean operations and sustainability in MSMEs. Most of the prior studies on sustainability, considered lean, just as a means for waste reduction and the consequent benefits of environmental protection.

However, some prior studies have mentioned some of the broad areas of linkage between lean and sustainability in large-scale industries. There is a need to identify all the relevant areas of linkage between lean practices and sustainability in MSMEs. The primary intention to ascertain whether there is any relationship between LMPs and sustainability performances in Indian MSMEs. Hence, following research questions were proposed concerning MSMEs.

1. What are the effects of lean practices on the sustainability performances of MSMEs?
2. What are the areas of linkage between lean and sustainability in MSMEs?

3. What are the factors affecting the areas of linkage between lean and sustainability in MSMEs?

1.3 RESEARCH OBJECTIVES

This study aims at contributing a new insight towards the effect of LMPs on economic, environmental and social performances in MSMEs. The primary objectives of this study are grouped into five divisions as follows.

1. To identify the various lean manufacturing practices and sustainability performance measures in MSMEs.
2. To identify the areas of linkage between lean practices and sustainability in MSMEs.
3. To investigate whether the areas of linkage are same or statistically different for the MSMEs classified according to the levels of investment, manufacturing process, product category and the manufacturing sector belong to.
4. To assess the influence of lean practices on the sustainability performance of MSMEs.
5. To verify the interrelationship between triple bottom line sustainability performances

1.4 RESEARCH METHODOLOGY

The methodology adopted for this research work is explained in Figure 1.1. The steps followed are illustrated below.

1. Based on the literature review and discussion with subject experts, define the problem and formulate the preliminary framework for the study.
2. Design a questionnaire using the variables identified from the literature review and conduct pretesting and pilot survey before starting the survey.
3. Collect the data by surveying the firms belonging to MSMEs, which are representative of various product types, level of investment, manufacturing sector and manufacturing process to get the real representation of MSMEs.

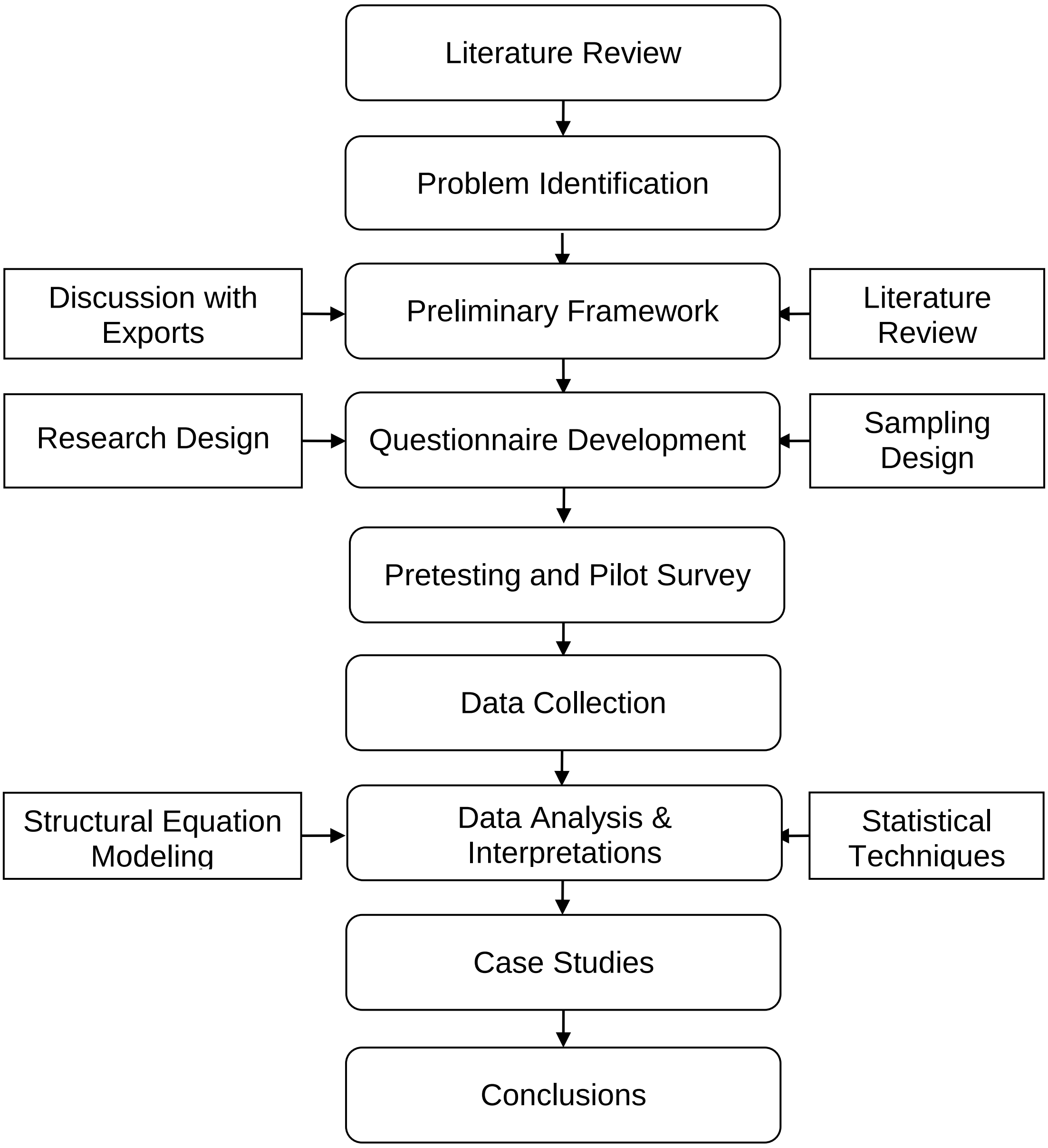

Figure 1.1 Research Methodology

4. Analyse the data to identify and interpret the relationship between the factors chosen using Structural Equation Modeling (SEM) and other statistical Techniques.
5. Conduct the case studies to check and validate the findings from the statistical analysis to throw the light on improvements possible.
6. From both statistical analysis and case study approach, conclude the major findings from this study.

1.5 STRUCTURE OF THE THESIS

This thesis comprises of eight chapters, organised logically to facilitate the reader to know the views of the author in accomplishing the aims of the study. Figure 1.2 provides the general idea of the structure of this thesis. The contents of each of these chapters are précised as follows.

Chapter 1 describes the introduction and background of the study in detail. The chapter also expresses the research motivation, research gap, research problem and the proposed objectives of the study. At the end of the chapter, the research methodology followed in this work is described. .

Chapter 2 titled 'Literature Review" describes LM in general and the various studies related to lean and performance improvements. The chapter discusses the suitability of LM approach towards the sustainable development of the manufacturing firms through the review of the literature. It also describes the classification of MSMEs in different regions and the nature of MSMEs in comparison with large-scale industries. The chapter fulfils the requirement of this study by identifying and describing LMPs broadly, selected from various literature related to MSMEs.

Chapter 3 presents the model developed for this work. The chapter lists and explains the constructs and variables of the model. The research design, stages of questionnaire development, pretesting and pilot survey, sampling method, and data collection methods adopted for the study are explained in this chapter.

Chapter 4 establishes the fundamental analysis of the level of adoption of LMPs in MSMEs and the important sustainability performance derived from these practices. This chapter also investigates the areas of linkages between lean and sustainability and the effect of contextual variables on the similarity of the respondents

Chapter 5 addresses the underlying structure of the variables of LMPs and sustainability performances using the data collected from the sample frame. This chapter explains the procedure of Exploratory Factor Analysis (EFA) and explores the underlying factors of dependent and independent variables

Chapter 6 presents the hypotheses developed about the relationship between LMPs and various factors of sustainability performance generated from chapter 5. The study describes the measurement model and structural model formed during the confirmatory factor analysis (CFA) and corresponding model fit details. The chapter gives the SEM results and interpretation of the results.

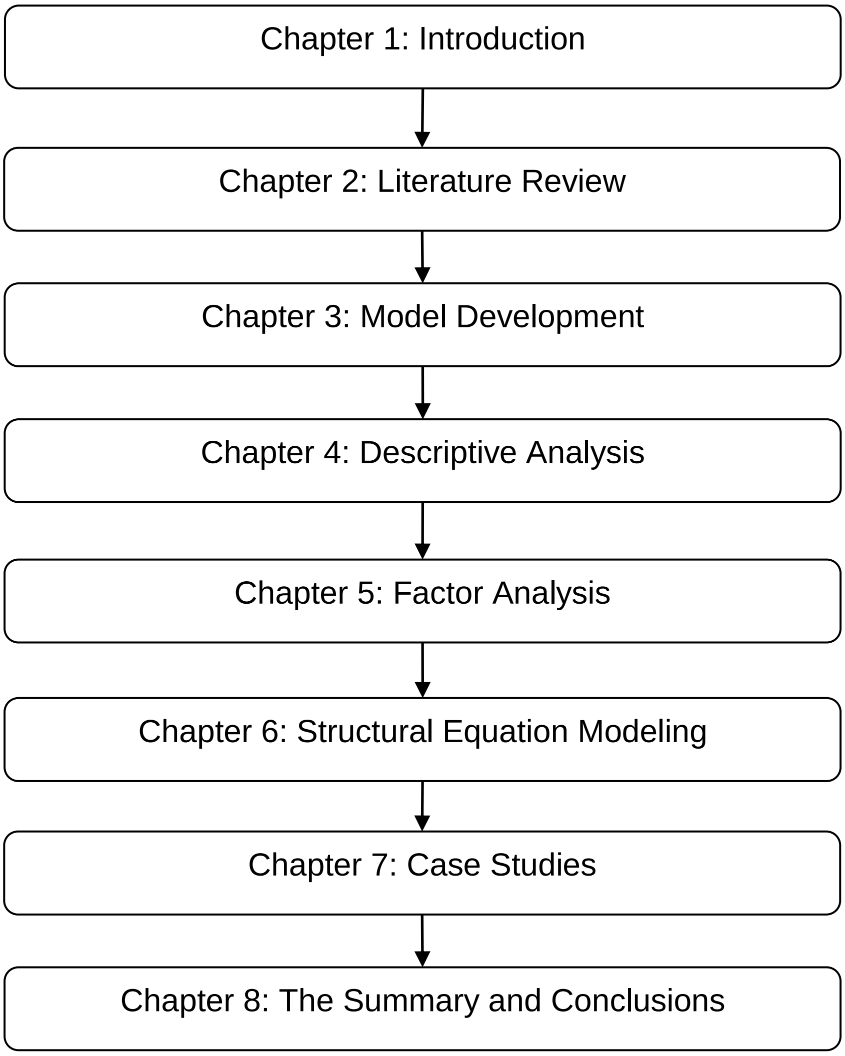

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Figure. 1.2. Structure of the Thesis

Chapter 7 presents the findings of the case studies conducted in five different manufacturing firms to verify the results of the statistical analysis presented in the previous chapters. The chapter ends with the conclusions from the findings of the case studies.

Chapter 8 presents the summary and conclusions of the present work. The chapter lists the findings from the study and the conclusions in detail. The chapter ends with the limitations and future scopes of the study.

1.6 CONCLUSION

A concise introduction to this study by stating the relevance of the LM and the sustainability concepts in the preview of MSMEs were presented in this chapter. The relevance of MSMEs in framing the industrial economies in different nations is also brought out. The research problem is stated, and further, the objectives of the study were outlined. The research methodology adopted for the study and the structure of the thesis were accounted at the end of the chapter.

CHAPTER 2
LITERATURE REVIEW

2.1 INTRODUCTION

A thorough search of the literature was accomplished to get the precise insight in the area of adoption of lean and sustainability of firms in general, and MSMEs in particular. The finding of the systematic literature survey helped the critical assessment of the available literature to gather the primary inputs required for this research and to emphasize the scope of the current objectives.

2.2 LITERATURE SURVEY METHODOLOGY

The methodology adopted for the literature survey and the relevant information collected are presented in the subsequent sections.

This review is performed in four stages. The first step is started by identifying the likely and sufficient databases using the appropriate keywords. The following key words "Lean manufacturing", "Lean manufacturing practices", “Lean Tools", "Lean Performances", “Sustainability", “Sustainability performances", "MSMEs” and “SMEs" are used for the search. A detailed search using these keywords stated above, individually and in combinations, was conducted in general search engines or in the advanced search options of well known Journal publishers. This list of journals mainly include Science direct, Elsevier, Taylor and Francis, Emerald Insight, Inderscience, Springer and other academic journals. Hundreds of likely papers were collected whose abstracts and conclusions were initially examined. The documents found to be relevant were carefully studied.

In the second stage, the available works of literature are arranged orderly for useful reference. Initially, the concepts of lean and sustainability were reviewed from the materials. The history of lean manufacturing with its mechanism, principles of the sustainability concepts and the sustainability performance measures were studied.

Further general review of the papers, which direct the relevance of MSMEs or SMEs, its characteristics, classification criteria, contributions and the sustainability practices in MSMEs, were given attention. The significant performance improvements with the implementation of lean were reviewed. The following sections describe information gained in the subject area from the review of the literature.

2.3 HISTORY OF LEAN MANUFACTURING

Lean manufacturing is a philosophy evolved in Japanese companies and popularized in western countries with different names. Lean has also been known as 'Toyota Production System' (TPS) as M/s Toyota Motor Company (TMC) is being recognized as the origin of lean production (Shah & Ward 2007). Lean has also been known in different titles as Just in Time (JIT), pull manufacturing and Total Quality Management (TQM) as these concepts also incorporated some of the principles of lean.

The mass production concept of the transfer lines or assembly lines, 'Henry Ford' developed the model and introduced in the automobile industry, transfigured the production system that has existed up to that. Henry Ford outlined his philosophy which was recognized as'Ford Production system' (FPS) in 1927. This concept was later accepted in the other sectors in many countries including American companies. During the period of World War II, the increased competitiveness surged out of the mass production systems of American businesses caused fierce competition to the companies all over the world. The situation of Japanese companies also was under threat to face the competition from these American companies.

The performance of Japanese companies regarding cost was far behind the competitors from other countries due to the lack of natural resources, which forced them to import the raw materials from the other parts of the word. This state of affairs forced them to think somewhat different from the rest of the world, if they want to sustain in this fierce competition. The only solution that Japanese industries find to overcome this problem was by putting their best efforts to produce better quality goods having a higher added value and at even lower production cost as compared to other countries.

This situation led M/s. TMC to do a thorough study of the production system of the American automobile industry and in particular FPS. Toyota adopted the Fords practices to their transfer line with a goal of cost reduction. They identified the central role of inventory and introduced the quality movements by entering the quality circle, team development, cellular manufacturing, set up time reduction and small batches. The solution and changes offered by Toyota after testing on its assembly line led to a complete reconstruction of the company and soon gave way to the introduction of an alternative and unique production system referred to as the TPS (Ohno, 1988).

The success of this new manufacturing and management practice in productivity and quality improvements in M/s TMC created a profound interest in other companies worldwide. In continuation to this, in 1980's some American manufacturers, such as Omark Industries, General Electric and Kawasaki (Lincoln, Nebraska) also have achieved success with a title World-Class manufacturing. "The Machine That Changed The World" Womack's book was a straight forward account of the history of automobile manufacturing combined with a comparative study of Japanese, American, and European automotive assembly plants with LM.

2.4 THE MECHANISM OF LEAN SYSTEM

The initial acceptance of lean model was considered fit only for the manufacturing sector. Womack et al. (1990), was the first to use the term "Lean Enterprise" and describe it as the extension of the lean manufacturing approach to outside the boundaries of the organization. The journey towards a lean culture and its implementation is based on five principles on the processes of the firm (Womack and Jones, 1996; Piercy and Rich, 2009). These five fundamental principles of lean are value, value stream, flow, pull and perfection as discussed by Womack and Jones (1996). These lean principles, which lead to a lean enterprise, are briefly explained in the following paragraphs

1. **Value**: Value is something that the ultimate customer can determine. If there is a value that means, less waste has been created. The value actually means what, when and how does the customer want and the preferences they expect about quality, capability, and price of the product or service (Womack and Jones, 1996; Piercy and Rich, 2015)

2. **Value stream**: Value stream is the path that the product follows from the raw materials to the finished product that is required to deliver the product as specified by the customer. The three business processes involved in the value stream are problem-solving from design to launch, information management from order placing to delivery and physical transformation from raw material to the final product. The value stream consists of all the activities that are required to produce a product or service, whether they are value-added or non-value added (Womack and Jones, 1996; Seth et al., 2017).

3. **Flow**: Flow refers to ensuring the value-added activities essential to create and deliver a product or service flow without disruption. The communication and interface between the various stages of value stream occur in the flow process. The basic concept of flow is to change the perception of process-focussed efficiency to product targeted ability. In this perception, the interaction between various methods plays a significant role in the supply chain (Womack and Jones, 1996; Pannizzolo et al., 2012; Ogunbiyi, 2014).

4. **Pull**: It is considered as the driver that enables the value stream. Pull production makes the end customer responsible for initiating the production process. It works in synchronization with the value stream for satisfying the customer (Womack and Jones, 1996; Ogunbiyi, 2014).

5. **Perfection**: It is to seek improvements to the process continuously. It is the continuous investigation for identifying waste due to which the synchronized flows of production doesnot break (Womack and Jones, 1996; Ogunbiyi, 2014; Bhasin, 2012).

2.5 LEAN MANUFACTURING AND PERFORMANCE IMPROVEMENT

A number of empirical studies have been conducted on the effect of the lean approach on various performance measures such as operational, financial and marketing performances of both service and manufacturing firms. These studies include conceptual studies, case studies, and simulation studies to identify the effects. On a closer watch, it can be seen that most of the researchers have investigated the likely impacts of the lean approach on these performances (Shah and Ward, 2003) without much emphasis on the theory of this philosophy. The most of the researchers have investigated the isolated effect of lean practices on performances. Later, many researchers proposed that lean practices should be classified into and examined as a set of internally consistent groups of practices known as 'lean bundles'. It can be seen that the researchers have made efforts to group the interdependent lean practices having common characteristics to meaningful lean bundles and tried to understand effects of these bundles on performances.

2.5.1 EFFECT OF INDIVIDUAL LEAN PRACTICES ON PERFORMANCES

Flynn et al. (1995) conducted a study using the data from 42 plants of three US industries on the interactive effects of TQM, JIT and infrastructure practices. This study concluded that TQM practices and JIT practices are mutually contributing each other while common infrastructure practices provide a strong foundation for TQM and JIT practices. This study highlights the synergistic and interaction effect among TQM, JIT, and common infrastructure practices.

Powell (1995) analysed in 54 firms in the service and manufacturing sectors about the influence of 11 lean practices under Human resource management (HRM) and TQM practices on the financial performances such as profitability, sales growth and overall financial performance. The study identified a better performance of the firms, which adopted TQM practices than the firms not adopted. The study reveals that the leadership, open organization and employee empowerment as the specific practices which are contributing significantly to financial performances. These findings bring out the importance of the social practices than technical practices for improving financial returns of the service and manufacturing organisations.

Effects on operational performances, namely customer satisfaction, employee morale, productivity, quality and delivery of manufacturing firms were analysed by Sampson and Terzioviski (1999). They have identified a significant positive effect by six practices, termed as leadership, people management, customer focus, strategic planning, information analysis, and process management coming under HRM. Correspondingly, Kaynak (2003) identified the effect of HRM practices among the TQM practices and the consequent progress on operational and financial concerts. This study was conducted among 214 firms comprising of 85% manufacturing and 15% service organisations in the US to explore the relationship between seven lean practices. The direct and indirect effects of the practices such as supplier quality management, leadership, training, employee relations, quality, data and reporting, process management, and product/service design were analysed using Structural Equation Modeling (SEM) Method.

An empirical study of lean practices conducted on 76 tile manufacturing industries in Spain by Bonavia and Marian (2006) identified a set of practices, including group technology, kanban, reduction of set-up time, development of multi-function employees and visual factory are scarcely implemented. In addition, another set of methods including standardization of operations, total productive maintenance (TPM), and quality controls have widespread usages. These findings reveal that the degree of utilization of lean practices depends on a firm's size and have a positive relationship with the operational performance.

Ghosh (2013) conducted studies in 79 manufacturing firms in India on the status of the acceptance of lean practice and their outcome on operational performances. Another outcome of this work is that about 80 percent of the organisations have implemented many dimensions of lean philosophy. The study reveals the three primary drivers of lean implementation are first-pass correct output, reduced manufacturing lead-time, and increased productivity.

A consolidated list of the studies conducted on the effect of LMPs on performances with tools used for analysis, sample size, and the type of industry where studies are conducted is shown in Table 2.1.

Table 2.1 Effect of Individual Lean Practices on Performances

Sl. No	Author	Description of Research	Tools for Analysis	Sample Size	Type of Industry
1	Flynn et al.(1995)	Effect of 9 individual LMPs on two operational performances	Hierarchical regression	42	Manufacturing
2	Powell (1995)	Effect of 11 individual LMPs on three financial performance measures	Correlation analysis	54	Service and manufacturing
3	Samson and Terziovski (1999)	Effect of 6 individual LMPs on five operational performances and 3financial performances	OLS regression	1024	Manufacturing
4	Kaynak (2003)	Effect of 7 individual LMPs on nine operational performance measures	SEM	214	Manufacturing and service
5	Bonavia and Marin (2006)	Effect of 11 individual LMPs on four operational performance measures	Friedman's non-parametric test, Wilcoxon tests, Mantel-Haenszel common odds ratio	76	Ceramic tile manufacturing industries in Spain
6	Bonavia and Marin-Garcia (2011)	Effect of 12 individual LMPs on eight operational performance measures	ANOVA, discriminant analysis	76	Manufacturing
7	Talib et al. (2013)	Effect of 17 individual LMPs on six quality performance measures	OLS regression	172	Service Industry
8	Ghosh (2013)	Effect of 7 individual LMPs on six operational performance measures	Multiple Regression	79	Manufacturing firms from four geographical regions in India

2.5.2 EFFECT OF LEAN BUNDLES ON PERFORMANCES

In order to avoid the deceptive results from analysis of individual practice effects, researchers began to group lean practices, which were interdependent by some of the commonalities, and to identify the effect of this groups or bundles on the various performance measures. The most important studies of this category were done by Shaw and ward (2003), Pont et al. (2008), Rahman et al. (2010), Bonavia and Marin-Garcia (2011), Agarwal et al. (2013), Furlan et al. (2011, Yang et al. (2011).

Based on a sample of 163 manufacturing organisations from four countries (United States, Japan, Italy, Germany, and the United Kingdom), Cua et al. (2001) studied the effect of three lean bundles namely, TQM, JIT, and Total productive maintenance (TPM) on manufacturing performances namely quality, on-time delivery, flexibility and cost efficiency. The major findings of this work include that organisations following the combination of the above bundle practices have higher manufacturing performances than focusing only one bundle. This study also brought out the existence of a positive relationship between LMPs and manufacturing performances. Shaw and Ward (2003) conducted a Hierarchical regression analysis by introducing four Bundles TQM, JIT, TPM, and HRM by collecting the data from 1757 US manufacturing plants to study the effect on operational performance. Table 2.2 gives a consolidated list of studies with tools used for analysis, sample size, and the type of industry where the study is conducted.

Table 2.2 Studies on Effect of Lean Bundles on Performances

Sl.No	Author	Description of Research	Tools for Analysis	Sample Size	Type of Industry
1	Sakakibara et al. (1997)	Effect of two lean bundles (Infrastructure and Quality) on seven operational performance measures	Canonical correlation analysis	41	Manufacturing
2	Cua et al. (2001)	Effect of four Bundles(TQM, JIT, TQM, Common practice) on four operational performances	Discriminant analysis	163	Manufacturing plants located in the United States, Japan, Italy, Germany, and the United Kingdom
3	Shah and Ward (2003)	Effect of four Bundles(TQM, JIT, TQM, HRM) on six operational performances	Hierarchical regression analysis	1757	Manufacturing firms from the US

Sl.No	Author	Description of Research	Tools for Analysis	Sample Size	Type of Industry
4	Pont et al. (2008)	Effect of three bundles (Jit, TQM, HRM) on six operational performance measures.	SEM	266	Manufacturing plants located in nine countries: Finland, Sweden, Germany, Japan, Korea, Austria, Italy, Spain and the United States.
5	Rahman et al. (2010)	Effect of three bundles (JIT, Waste elimination, Flow management) on four operational performance measures.	OLS regression	187	Manufacturing firms, including SMEs and large scale industries in Thailand
6	Agarwal et al. (2013)	Effect of three bundles(Operations management, Performance management, people management) on two operational performances and five financial performances	Panel data, OLS regression	152	Manufacturing
7	Furlan et al. (2011)	Effect of three bundles (JIT, TQM, HRM) on five operational performance measures	ANOVA, Tukey test, OLS regression, F test	26	Manufacturing
8	Yang et al.(2011)	Effect of three lean bundles(JIT flow, Quality management, employee involvement) on two financial performances, two marketing performance and on environmental performance measures	SEM	309	Manufacturing firms from Europe, and North/South America, Asia Pacific, and Turkey

2.5.3 EFFECT OF LEAN PRACTICES IN SME PERFORMANCES

Filho et al. (2016) surveyed to identify the degree to which LMPs are being implemented on Brazilian SMEs and to investigate the effect of these practices on operational performances using SEM technique. The study brought out that even though the Brazilian SMEs have implemented the LMPs in a fragmented manner, these practices have lead to a better operational performance. The statistical process control, TPM and employee involvement are the three practices that are implemented in an integrated approach for Brazilian SMEs. Customer involvement, continuous flow, pulls production, set-up time reduction, supplier development and supplier feedback are the practices that are adopted by SMEs, but in a dispersed manner. Researchers have also studied the effect of LMPs on MSMEs all over the world. Table 2.3 gives a summary of these studies conducted in four different countries.

The study conducted among the food processing SMEs in Belgium, Germany, and Hungary by Dora et al. (2013) revealed that the usage of LMPs in these countries are in its early stages. SMEs in the food sector are less focused on the process improvements; their main attention was on the food safety and quality management. The analysis also underlined that the use of the LM helps to improve the operational performance, especially, productivity and quality.

Pannizolo et al. (2012) conducted a study to examine the acceptance and deployment of lean practices in Indian SMEs. The case studies in four Indian SMEs observed that all the four firms had attained significant operational benefits grouped into upstream, internal and downstream value stream performances from the implementation of LM.

Table 2.3 Studies on LMPs Effects on SMEs Performances

Sl. No	Article	Type of Study	Statistical Analysis	Sample Size	Type of Industry
1	Filho et al. (2016)	Effect of LM on operational Performance	SEM	52	SMEs in Brazil
2	Dora et al. (2013)	Effect of LM on operational performance	Descriptive Statistics	35	European Food Processing SMEs
3	Panizzolo et al. (2012)	Effect of LM on operational Performance	Case studies	4	Indian SMEs
4	Zhou (2012)	Impacts of lean on SMEs	ANOVA test	34	SMEs in U.S

2.6 SUSTAINABILITY

The concept of sustainability has come forward as a result of significant trepidation about the involuntary social, environmental, and economic consequences of the developmental activities. 1972 Stockholm United Nations (UN) conference on the Human environment is the first international initiative to discuss the sustainability issues at the global level. In continuation to this, UN appointed a World Commission on Environment and Development (WCED) under the chairmanship of 'Gro Harlem Brundtland' who had served three terms as Prime minister of Norway. In 1987, this commission published the report, "Our Common Future" defined the term sustainable development According to this report, sustainability means, meeting the needs of current and future generations through integrating environmental protection, social advancement and economic prosperity.

According to the definition of the 'Environmental Protection Agency' (EPA 2003) in US "Sustainability creates and maintains the conditions under which humans and nature can exist in a productive harmony, that fulfill the social, economic and other requirements of the present and future generations." 'Business sustainability' is a term getting attention from the industrialists today. The Institute for Sustainability (2011) defined business sustainability as "an increase in productivity and reduction of consuming resources without compromising product or service quality, competitiveness, or profitability while helping to save the environment".

Gagnon et al. (2009) defined sustainability in the development context as "a development that allows every people globally to at least meet their basic needs, if it provides individuals in a given society equal opportunities to increase their quality of life, and if it provides future generations increasing opportunities". Further, Seliger et al. (2011) defined sustainable products and processes in the manufacturing context, as "those conserve energy and natural resources, have minimal impact upon the natural environment and society, and adhere to the core principle of considering the needs of the present without compromising the ability of future generations to meet their own needs". Sustainability deals the synchronization of all events with the natural world around us, protecting it from damages and destructions (Swarnalatha and Binu, 2016) All these definitions of sustainable development and manufacturing originated from the fundamental "Brundtland" definition.

With the help of stakeholders, manufacturing firms, including MSMEs and large companies are trying to enrich their sustainability performance by continuously improving their product and operations (Russo and Tencati, 2009). The UN General assembly (2005) recognized economic and social developments and environmental protections as the goals of the sustainable development during the World summit on Social development. As mentioned by researchers around the world, sustainability integrates economic, social and environmental goals and objective of the organisation (Koho et al., 2015; Klewitz and Hansen, 2014; Hart and Milstein, 2003; Wang et al., 2015; Gimenez et al., 2012). These three elements represents the three pillars of sustainability (Garetti.and Taisch, 2012) and are mutually dependable, reinforcing and support each other as in the long run none can exist without the others.

2.7 LEAN APPROACH IN SUSTAINABLE MANUFACTURING

Lean practices are one of the manufacturing strategies towards achieving the sustainable advantageous. The core objective of lean manufacturing is the elimination of all forms of waste and thus reducing the non-value added activities from the manufacturing processes. At the same time, material waste elimination has been identified as the most efficient and cost-effective approach to promote sustainable practices of industrial concerns. Most of the prior studies on sustainability, consider lean, just as a means for waste reduction and the consequent benefits of environmental protection. The ‘zero waste’ or ‘zero defect’ target of LM aims the optimum use of the resources by reducing the material, energy, and space and time requirements for producing an output (Florida 1996).

Lean practices improve the operational performances such as delivery time, speed, quality and flexibility and these improvements catalyse the cost reduction process (Khanchanapong et al., 2014, Bortolotti et al., 2015). Better operational performances bring prospects for the manufacturer to speedily respond to fierce competitions by producing high-quality products at reasonable costs, in a manufacturing cycle (Aguado et al., 2013). The operational cost reduction positively affects financial performances of the firms (Hofer et al. 2012). Reducing the waste in the form of scrap or rework and improving the productivity, decrease the cost of the organization and increase the ‘return on assets’ and profit (Yang et al., 2011). As an example, inventory reduction, waste elimination, and reduction of the volatile organic compound (VOC) are the some of the benefits of the Just in Time (JIT) practices (Rothenberg et al., 2001). These advantages indicate the positive effect of lean on the economic and environmental sustainability performances of the firms (Nahmens and Ikuma, 2012).

Environmental sustainability performances focus on the environment by addressing the use of materials, energy and the management of pollution and waste. The lean operational performances and environmental sustainability performances are complimentary (Martínez-Jurado and Moyano-Fuentes, 2014). Adoption of TQM practices enhances the level of quality achievement, which helps organizations to improve their market acceptance (Mosey et al., 2003). This practice has significant effects in maintaining a high quality work environment, which enhances the potential for controlling the overall manufacturing operations. This situation also increases the ability to eliminate the usage of hazardous processes in manufacturing activities causing negative impact on the environment (Demeter and Matyusz, 2011).

Adoption of lean practices amplifies the intensity of responsiveness addressing new manufacturing requirements, environmental issues, economic issues, and increase the level of competency in fulfilling the social needs for establishing sustainable manufacturing environment (Vithayasrichareon et al., 2012; Yusup et al., 2015). According to Longoni et al. (2013), the lean strategy intends the respect for people, followed by continuous process improvement. Sustaining a positive reputation in the local community is an unambiguous part of the strategy-setting process within the lean organization (Piercy and Rich, 2015). As evidenced by Indian small-scale industries, lean practices attempt to empower the workers, increase the job satisfaction and create a pride of work (Jain and Malik, 2013).

Improvement in the employees working conditions is one of the mutual benefits of lean and sustainability (Piercy and Rich, 2015). Lean operations such as visual management, employee training, and work standardization, bring higher levels of safety in a manufacturing space (Cudney et al., 2015). Thus LM is contributing towards 3BL sustainable dimensions such as economic, social and environmental benefits of manufacturing firms (Nahmens and Ikuma, 2012; Ogunbiyi et al., 2013)

2.8 AREAS OF LINKAGE BETWEEN LEAN AND SUSTAINABILITY

LM is a managerial philosophy, which consists of a set of interrelated social and technical practices (Womack et al., 1990). LM has been concentrating on the elimination of seven deadly wastes (Womack and Jones, 1996) from the manufacturing system. LM aims the reduction of material, energy, space and time requirements for manufacturing processes, which leads to environmental sustainability advantageous. (Florida 1996; Miller et al., 2010).

In addition to environmental and waste reduction, modern researchers have defined some additional scopes of integrating lean and sustainability (Oyedolapo et al., 2013; Piercy and Rich, 2015; Azevedo et al, 2012; Wang et al, 2015; Rothenberg et al, 2001; Cudney et al, 2015). Piercy and Rich, (2015) have identified more possibility of lean actions on sustainability, namely supply monitoring, transparency, workforce management, and community engagement. Firms also trying to cope up the social demands along with the environmental needs with lean practices (Murillo and Lozano, 2006). Focused on improved employees working condition, large-scale industries as well as MSMEs are adopted various lean practices (Cudney et al., 2015; Piercy and Rich, 2015). Lean practices also attempt to empower the workers, increase the job satisfaction and create a pride of work (Jain and Malik, 2013). The common areas such as health and safety management, continuous improvement, and community strategy also come under the preview of linkage between lean and sustainability. Other areas of linkage include better quality, performance improvement, cost reduction, energy minimization, transparency, value maximization and governance etc.(Azevedo et al., 2012; Piercy and Rich, 2015; Oyedolapo et al., 2013).

2.9 MICRO SMALL AND MEDIUM ENTERPRISES

MSMEs differ immeasurably because of their explicit owners, custom/culture, employees, and market conditions and so on. MSMEs are owned by single owners or entrepreneurs and are managed with smaller resources. The majority of the companies under micro and small categories are privately owned. Some MSMEs are limited companies, which offer advantages in handling financial risks and taxes. However, the large business firms are corporate owned and managed in a well-maintained and controlled fashion. The number of the employees and availability of the resources and the market approachability are more in large firms.

Table 2.4 Comparison of Features of MSMEs and Large-Scale Firms

Sl.No	MSMEs	Large Enterprises
1	Owned by Single entrepreneur or small group	Corporate ownership / professional management
2	The equity held by founder/ family and private groups	Public investor held the equity
3	Decision-making largely by owner / CEO and some key leaders (single or dual)	Distributed decision making by organization's hierarchy
4	Organization structure is flat	Organization structure is more wide, vertical
5	Single layer and Owner is at the core	Have multiple and detailed layers of ownership
6	Capital needs to be met by leveraging personal net worth	Wide range of funding sources
7	Flexibility in operations and decision making is more	Flexibility is less in decision making
8	Low economies of scale	Higher economies of scale
9	Limited personal development opportunities	Multiple career development path and programme
10	Make use of labour-intensive technologies	Automation oriented technologies and technology management are more efficient
11	Labour cost affects productivity	Better productivity
12	Small/limited customer base	Diverse / Global markets and customers
13	Mostly informal and few formal processes. People dependent processes.	Formal structure and processes and mostly people independent.
14	Low economies of scale	Higher economies of scale

In MSMEs, decision-making is done by the owner itself or by the key person in charge, and the organizational structure is flat (Singh et al. 2010). As the formal organizational structure is not there in MSMEs, it is accessible to decision making, and the operational flexibility is more compared to large enterprises (Floyd and McManus

2005). In large enterprises, there exists an organizational hierarchy to take the decisions, and the organization structure is vertical with multiple layers. This situation reduces the flexibility in decision making in large enterprises. MSMEs are raising funds for day to day operations and other development activities on the influence personal net worth. MSMEs are free from bureaucracy and controlled by a self-active and motivated management and employees through a small communication network (O' Regan and Ghobadian, 2002). However, the lack of expertise, time, money and managerial and technical support are the drawbacks of MSMEs in general (Singh et al., 2008). A comparison of MSMEs and Large enterprise is tabulated in Table 2.4.

2.10 CLASSIFICATION OF MSMEs

MSMEs are present in all the contries of the world. However, MSMEs are classified differently in different nations. The abbreviation "SME" is used in the European Union and by international organizations such as the World Bank, the United Nations and the World Trade Organization (WTO). According to European Commission (2005), "SMEs are the firms employing fewer than 250 persons and an annual turnover not exceeding 50 million Euros, and the annual balance shall total not exceed 43 million Euro".

In UK, in the beginning of 2014, 99.3% of the private sector businesses were SMEs. SMEs in the UK are classified based on two out of three criteria; it has a turnover of a less than 25million pounds, it has fewer than 250 employees, it has gross assets of less than 12.5 million pounds (Department for business innovation & skills, 2012). In the US, Small and Medium manufacturers referred to SMMs are defined as the enterprises with less than 500 employees and has an annual gross sale under 100 million dollars (Hu et al., 2015).

In African countries, SMEs are classified differently. In South Africa, less than 200 full time paid employees and an annual turnover of fewer than 51 million Rands (Urban and Naidoo, 2012) characterizes SMEs. In Kenya, the firms are known as MSMEs. Microenterprises are those with a number of employees up to 10, small enterprises with 10 to 50 employees and medium businesses with 50 to 100 employees. In Egypt, around 85 percent of the enterprises are classified as small-sized with employing less than 20 workers, which indicates the most of the firms in Egypt are micro or small enterprises (El-said et al., 2014). Around 2.5 Million SMEs are employing 75% of the total workforce and 99 % of non-agricultural private sector establishments.

In Asian countries, Bangladesh classified SMEs based on Fixed Asset and Employed Manpower. In Singapore, SMEs are businesses with the annual sales turnover of not more than $100 million or employing no more than 200 staff. However, in China, SMEs are defined very differently and also varies slightly from time to time. The Ministry of Industry and Information Technology (MIIT) of China amended the SME criteria in2011. According to this amendment, in China, small industries are those having numbers of employees less than 300 and total annual sales less than 20 million RMB while medium sectors are those having no of employees between 300 to 1000 and annual sales 20 to 400 RMBS.

Table 2.5 Classification Criteria of MSMEs in India

Class/Category	**Manufacturing**	**Service**
Micro Enterprises	Investment up to Rs.25 lakhs	Investment up to Rs.10 lakhs
Small Enterprises	Investment above Rs.25 lakh and up to Rs.5 crore	Investment above Rs.10 lakh and up to Rs.2 crore
Medium Enterprises	Investment above Rs.5 crore and up to Rs.10 crore	Investment above Rs.2 crore and up to Rs. 5 crore

In India, the classification of firms is based on the investment in plant and machinery as defined according to the Act 'Micro, Small and Medium Enterprise Development (MSMED) Act -2006'. Enterprises are classified broadly into (i) Enterprises engaged in the production of goods about any industry and (ii) Enterprises engaged in providing/rendering services. The grouping into Micro, Small and Medium firms in the service and manufacturing sectors are shown in Table 2.5. The manufacturing and service enterprises have been further classified into micro, small and medium based on investment in plant and machinery and in equipment respectively. As per the section 7 of the Act, a manufacturing organization is classified as medium-sized enterprise if the investment in plant and machinery is between 50–100 million Indian Rupees, microenterprise if the investment is a maximum of 2.5 million Indian Rupees and small enterprise if the investment is between 2.5 and 50 million Indian Rupees

2.11 CONTRIBUTIONS OF MSMES

World over, MSMEs or SMEs are contributing significantly to the industrial economy as well as to the economic growth through innovation, higher production volume and employment generation (Hu et al., 2015; Bhamu and Sangwan, 2014). The contributions from these firms for the economic and social developments of various countries cannot be neglected as the majority of industrial firms in these countries are under this category.

Over 99 percent of companies as well as business accounts for SMEs in the US and the majority of the countries in Europe and Asia (The Economist, 2010; Business, Innovation and Skills, 2010). In Europe, SMEs employ about two-thirds of a workforce and generate a significant share of new jobs. The contributions of SMEs in different countries from the various continents, recorded under the heads of the percentage of manufacturing output, employment, export and GDP are shown in Table 2.6.

Table 2.6 Contributions of MSMEs in Different Countries

Country	**Share of Total**			
	Output %	**Employment %**	**Export%**	**GDP %**
USA	-	53	-	40
UK	44	-	38	35
Japan	52	72	13	-
Taiwan	81	79	48	-
Singapore	32	58	16	25
Korea	33	51	40	-
Malaysia	13	17	15	35
Indonesia	36	45	15	-
India	40	45	40	8

In South Africa, SMEs are inevitably synchronized to economic development and the employment and social development of the country (Davies, 2001; Urban and Naidoo, 2012). The SME segment has grown as a very effervescent and active sector of the Indian economy in the last five decades (MSME, 2012). This sector is playing a crucial role in the industrialization of under developed areas, assuring equal sharing of national income and capital, thereby the socioeconomic development of the country. Indian SMEs account for 95 percent of the total industrial units, 45 percent of industrialized output, 40 percent of entire exports, and the primary provider of employment opportunities for the country (Singh et al., 2008; MSME, 2012).

2.12 LEAN IMPLEMENTATION IN MSMEs

Different authors have investigated and reported the use of lean tools that are suited for MSMEs (Gunasekaran and Lyu, 1997; Lee, 1997; Kumar et al., 2006 ; Rose et al., 2013, Sohal and Naylor, 1992; Lee, 1997; Abdul-Nour et al., 1998; Roth and Franchetti,2010). But there is a shortage of research focusing on Lean in MSMEs compared to large enterprises. The general inference from these studies is that SMEs are more selective than large enterprises, in the adoption of lean tools that to be implemented (Hu et al., 2015).

SMEs have been selecting inexpensive and straightforward lean tools due to the financial, time and technical constraints (Mathur et al., 2012). Value Stream Mapping, Kanban and 5S/6S workplace organization, standardised work and TPM are fairly popular tools and are frequently discussed in the SME lean literature (Hu et al., 2015). Some of the lean tools, which are very predominantly used in large enterprises, is not popular in SMEs (Bhasin, 2012). The most dominant areas of lean implementation in SMEs is internal production or operations with a principal objective of waste reduction on the shop-floor.

The criteria for assessing the impact of lean in SMEs are efficiency factors such as waste reduction, cost reduction, quality and productivity improvement and effectiveness factors such as organizational culture, employee empowerment and employee motivation, interest and ability (Hu et al., 2015). Various studies have identified that, employee involvement and participation (Ramaswamy et al., 2002; Kumar et al., 2006; Panizzolo et al., 2012), top management support and commitment (Panizzolo et al., 2012; Rose et al., 2014; Timans et al., 2012), training and education (Timans et al., 2012; Dora et al., 2013) and organisational culture change (Timans et al., 2012; Dora et al., 2013; Ravikumar et al.,2013) are recognised as crucial Critical Success Factors (CSFs) for the implementation of Lean in SMEs. Financial capability (Achanga et al., 2006; Ravikumar et al., 2013) Supply chain integration (Rose et al., 2014; Timans et al., 2012), Personal experience (Timans et al., 2012) and other Technical factors are found to some of the CSFs.

Table 2.7 Success and Failure Factors of Lean Implementation

Sl.No	Supporting factors	Hindering factors
1	Management commitment	Reliability of one person management
2	Quick decision-making process	Intuitive rather than analytical decision making
3	Faster communication with employees , suppliers	Employee absenteeism
4	Greater flexibility	Fluctuation in raw material availability and prices
5	Business strategy based on customer demand	High rejection rate
6	More authority and power to employees	Shortage of skilled employees
7	An innovative environment	Inadequate financial resources
8	Support to change initiatives	Insufficient time and cash flow management
9	Shop floor commitment and employee trust	Reliance upon outdated, labour-intensive technologies and traditional management practices
10	Linking lean into business strategy	Inadequate education and training of entrepreneurs

Table 2.7. shows the supporting and hindering factors of lean implementation in SMEs (Pannizzolo et al., 2012; Upadhye et al., 2013; Rymaszewska 2014; Ramadas et al, 2016). There are different opinions about the capability of SMEs to adopt lean practices based on their organizational characteristics. Seitz (2003) argued that SMEs are more capable to easily adopt lean practices due to their supportive characteristics to the espousal towards lean. Faster communication, quick decision making, greater flexibility in decisions, more responsive to customer needs are the some of the

positive, supportive factors of for easy adoption of lean manufacturing by MSMEs (Floyd and McManus 2005). Unified organizational culture, employee empowerment, centralized power and innovative environment are the favourable circumstances to lean adoption in SMEs (Deros et al. 2006, Seitz 2003; Rymaszewska 2014).

There are some organizational characteristics of SMEs which obstructs and delays the approval and acceptance of lean practices in them. Lack of resources, particularly, fund and skilled workforce, fluctuation in raw material availability in regular price, inadequate cash flow are some of the characteristics of SMEs, those act as obstructs to learn adoption (Pannizzolo et al., 2012; Rymaszewska 2014; Mathur et al., 2012).

2.13 INTEGRATION OF LEAN AND SUSTAINABILITY IN MSMES

MSMEs all over the world are contributing significantly to the industrial economy through economic growth, innovation, and employment generation. MSME segment has grown as a very effervescent and active sector of the Indian economy in the last five decades (MSME, 2012). This sector has been playing a crucial role in the industrialisation of underdeveloped areas, assuring equal sharing of national income and capital and thereby the socio-economic development of the country.(Singh et al., 2008; MSME, 2012).

With the help of stakeholders, manufacturing firms, including MSMEs are trying to enliven their sustainability performance by modifying their product and operations (Russo and Tencati, 2009). Recent studies have shown a positive link between environmental performance and financial performance of the small firms (Clemens, 2006; Murillo and Lozano, 2006; Russo and Tencati, 2009). MSMEs are trying to improve their environmental performances within their resource limitations. (Johansson and Winroth, 2010; Lepoutre and Heene, 2006). MSMEs are also trying to cope up the social demands also with the environmental demands and their implementation practices (Murillo and Lozano, 2006).

According to Longoni et al. (2013), the lean strategy intends the respect for people, followed by continuous process improvement. Sustaining a positive reputation in the local community is an unambiguous part of the strategy-setting process within the lean organisation (Piercy and Rich, 2015). The common areas such as health and safety management, continuous improvement, and community strategy are integrated into the preview of linkage between lean and sustainability. Similarly, many areas of linkage between lean and sustainability can be identified according to primary concerns and objectives. Other areas of linkage include better quality, performance improvement, cost reduction, energy minimisation, etc. (Azevedo et al., 2012).

2.14 LEAN AND SUSTAINABILITY STUDIES INDIAN MSMES

The status of implementation and awareness of lean philosophy in Indian industries are not so clear and encouraging. (Thanki and Thakkar., 2014; Saboo et al. 2014; MSME, 2013). In a recent study by Filhoa et al. (2016) have pointed out that, in BRIC countries which refers to countries of Brazil, Russia, India and China, which all are deemed to be the similar stage of emerging economies; a very little studies have been reported in the SMEs about the lean performances. Similarly, Thurer et al. (2013) have mentioned the necessity of more researchers on SMEs in BRIC countries as the countries moving together as advanced economic reforms.

The development of sustainable MSMEs becomes an important step to strengthen and sustain Indian economy (MSME, 2013). Govt. of India has implemented lean manufacturing competitiveness improvement scheme for MSMEs and looking forward the sustainable growth of them. However, Indian MSMEs have been consistently performing on crucial parameters such as production, employment and role in the global market (MSME, 2012). As evidenced by Indian MSMEs, lean practices attempt to empower the workers, increase the job satisfaction and create a pride of work (Jain and Malik, 2013). These firms have shown consistent growth rate, both under a protected economy and an open economy and they are of vital importance to the future economic growth of the Indian community, as well as the international market (MSME 2012). To sustain this role, they need support in defining their specific managerial needs and in finding the right approach to respond to them (Dangayach and Deshmukh, 2005).

2.15 CONCLUSION

This chapter highlights the review of the literature related to lean manufacturing and sustainability. In this review, the development stages, the basic principles, relevance and the possibilities of integration of both these concepts in the manufacturing locale are examined. The characteristics of MSMEs were also explained. The importance of MSMEs in the various economies in the word with their own limitations is substantiated by this review. The review on performance studies of lean implementation in manufacturing firms clearly indicating that lean is an effective method for the betterment of the manufacturing firms.

The changes in the regulations along with the high assertion from multiple stakeholders, forced manufacturers to pursue the sustainable manufacturing practices. The latest researches have accepted that lean practices have a considerable effect on the continuous performance improvement achievements in manufacturing sectors (Yusup et al., 2015). In unison, researchers have started to integrate the lean principles into the sustainability aspects of the manufacturing. However, lean implementation has been mainly concentrated in large and multinational firms, and there is only less effort for implementation of lean in MSMEs is concerned.

It is already recognized that MSMEs are the most important element playing a significant role in the economic and social development of the most of the economies in the world. MSMEs have strengths and weaknesses to perform well in the competitive business world. They are considered as the base but not as the miniature of large size organization (Islam & Karim 2011; Antony et al., 2005). Hence, the tuning of the competitive advantages of the MSMEs into sustainable growth, will promote whole industrial world to contribute socially, economically and environmentally for the present and future generations

It is observed that the lean performance studies are primarily focused on operational performances and have no attention in the sustainable direction. The review also brought about the significance of sustainable growth and performance of the manufacturing MSMEs. This review established the shortage of studies in the integration of lean and sustainability concepts in the manufacturing firms and especially in MSMEs. It is also observed that there is not much literature formulating the model linking lean and sustainability performances using the SEM approach. So this review gives the clear research gap indicating the necessity of the study in the direction of lean effects on sustainability performance and the possibilities of integration of both these concepts in MSMEs.

CHAPTER 3
MODEL DEVELOPMENT

3.1 INTRODUCTION

This chapter aims at the model development for this research work. The theoretical foundation of the conceptual framework for the work has been outlined in this chapter. The constructs and the variables included in this theoretical model are identified and explicitly reported. The chapter starts with the description of the methodology adopted for this work. The selection of the appropriate and suitable method plays a significant role in any research work. This chapter also portrays the type of research, research framework, sample design, plans for the data gathering and the data analysis adopted for this work. The chapter ends with the conclusion of details of the model developed, identified constructs and variables in this model for further analysis.

3.2 RESEARCH DESIGN

The research, in general, comprises the search for knowledge (Kothari, 2004). According to Creswell (2008), "research is a process of steps used to collect and analyse information to increase our understanding of a topic or issue". This process consists of three steps, namely raise a question, collect the relevant information or data to find the answer and suggest the solutions to the question for the advancement of knowledge (Kothari, 2004).

The research design adopted for this study is descriptive research. Descriptive research is one of the simplest kinds of research. It describes a situation and involves a fact-finding investigation with adequate interpretation. According to Kothari (2004), "descriptive research includes surveys and fact-finding inquiries of different kinds and the major purpose of is the description of the state of affairs as it exists at present". A descriptive study is one in which information is collected without changing the environment The survey method and case study method are adopted for this descriptive research work.

3.3 RESEARCH MODEL AND FRAMEWORK

In this study, the relationships between LMPs with sustainability performance are investigated. Figure 3.1 depicts the model in which the dependent and independent variables are sustainability performance and LMPs respectively. Here dependent variable sustainability performance is influenced by Independent variable LMPs.

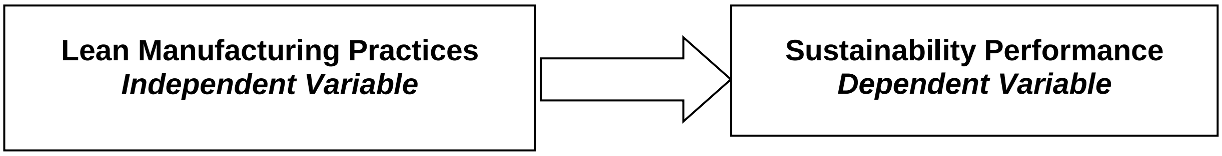

Figure 3.1 The Model Linking Lean Manufacturing Practices with Sustainability Performance

A framework was developed linking LMPs with sustainable performance as shown in Figure 3.2. Lean manufacturing practices are the input parameters in this framework. In the transformation phase, basic lean performance leads the sustainability performance of the firm.

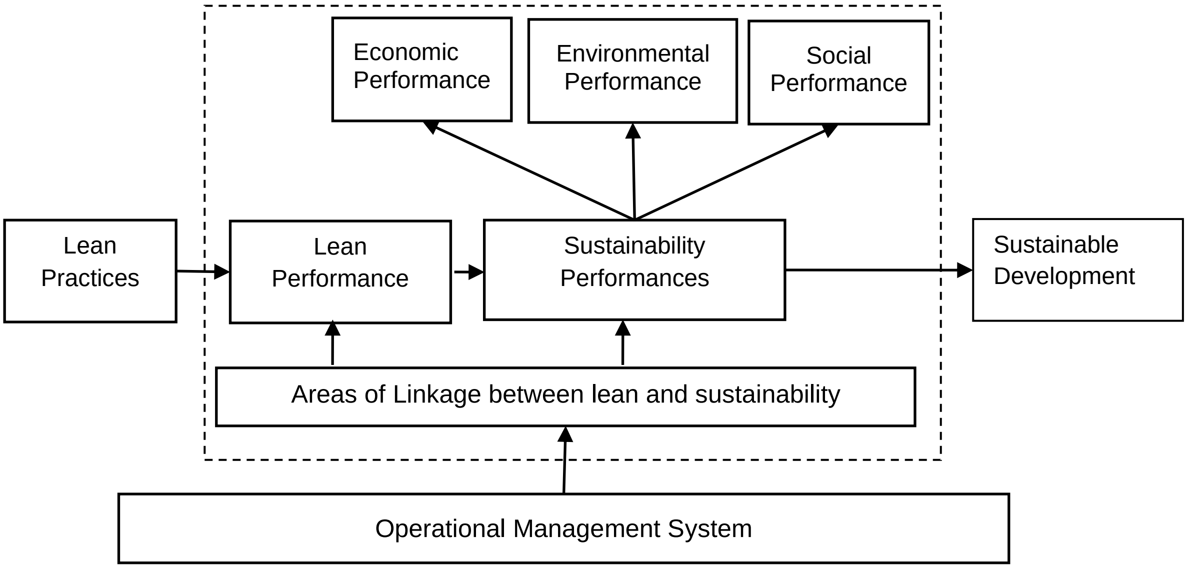

Figure 3.2 Framework Linking Lean Manufacturing Practices with Sustainability performaces (Reference: Yusup et al., 2015)

The LMPs are hypothetically supporting the establishment of sustainability performance in three pillars namely social, economic and environmental performances. The various areas of linkage between lean and sustainability are influenced by the operations management system existing in the firm.

3.4 CONSTRUCTS AND VARIABLES

In continuation to the literature review conducted in chapter 2, a detailed and orderly search was undertaken to find the appropriate variables in connection with the subject area of the research. This search was conducted with the suitable keywords or phrases like “lean manufacturing in SMEs, or MSMEs”, "sustainability performances" and "areas of linkage between lean and sustainability". The articles in which the keywords mentioned above are used in the title, abstract or list of keywords, were collected for further reference from well-known publishers like ‘Science Direct', ‘Emerald insight', ‘Inderscience' ‘Taylor and Francis' and ‘Springer'. These works of literature from the above searches are thoroughly examined for identifying the variables as described in the following subsections. The variables are identified under the three constructs namely “Lean manufactures Practices”, “Sustainability performances” and “areas of linkage between lean and sustainability”.

3.4.1 VARIABLES OF LEAN MANUFACTURING PRACTICES

The listing of the critical lean practices in MSMEs is a vital task to solve the incomprehension to the concept (Lewis, 2000). SMEs, in general, are unwilling to employ LMPs due to high fiscal investment and consultancy fees (Mathur et al., 2012). Major studies in connection with lean practices were conducted in large firms. The review of the literature on lean practices in MSMEs discloses varied views, about the relative significance of various lean practices. A total of 19 variables were identified to represent the construct "LMPs in MSMEs", and the quoted as statements to represent these variables Table 3.1 summarises LMPs in MSMEs according to the relevant works in the LM literature.

Table 3.1 Lean Manufacturing Practice Variables and Measures.

Sl.No	Variables	Statements representing the Variables	References
1	Workplace Organisation (5S)	Our plant emphasise putting all tools and fixtures in their proper place.	Lee (1997); Jain and Lyons (2009); MSME (2013); Zhou (2012); Upadhye et al. (2013); Wadhwa (2014); Roy (2011); Kumar et al. (2006).
2	Standard Operating Procedure (SOP)	We use standardised and documented processes which are well instructed to our employees.	Bonavia and Marian (2006); MSME (2013); Zhou (2012).
3	Setup Time Reduction	We focus to reduce process set up time - the time required to prepare or refit equipment, workstations, etc.	Bonavia and Marian (2006); MSME (2013); Panizzolo et al.(2012); Wadhwa (2014); Roy (2011); Rahman et al.(2010); Mathur et al. (2012); Saboo et al. (2014)
4	Total Productive Maintenance (TPM)	Workers carry out routine maintenance on all equipment (e.g., Cleaning, lubrication or small repairs) following standard procedures.	Bonavia and Marian (2006); MSME (2013); Zhou, 2012; Upadhye et al.(2013); Shaw and Ward. (2003); Kumar et al. (2006); Singh et al. (2008)
5	Small Group Problem Solving (SGPS)	Many equipment problems have been solving through small group sessions.	Bonavia and Marian (2006);
6	Preventive/Predictive Maintenance	Our plant following either preventive/predictive maintenance.	Lee (1997); Inman and Mehra (1990); Panizzolo et al. (2012); Shaw and Ward (2003)
7	Kanban (Pull system)	We use kanban pull system (or Containers of signals) for production control.	MSME (2013); Zhou, (2012); Upadhye et al. (2013); Powell et al. (2013); Wadhwa (2014); Saboo et al. (2014); Rahman et al. (2010)
8	Just in Time Purchasing	We can depend on- time delivery of our suppliers.	Zhou (2012); Panizzolo et al. (2012)

Sl.No	Variables	Statements representing the Variables	References
9	Supplier Relationship	We have built close, long-term relationships with our suppliers.	Gyampah and Gargeya.(2001); Panizzolo et al. (2012); Singh et al. (2010)
10	Early Information Exchange with Suppliers	We have high levels of information transparency or information sharing with our suppliers.	Panizzolo et al. (2012); Kim (2015); So (2015).
11	Self Directed Work Teams (SDWT)	We form teams capable of doing their daily work without formal leadership	Yang et al. (2011); Shaw and ward (2013)
12	Team Work	During problem-solving sessions, we make an effort to get all team members' opinions and ideas before making a decision.	Panizzolo et al. (2012); Khanchanapong et al., (2014)
13	Customer Focus	We systematically and regularly measure customer satisfaction	Cua et al. (2001).
14	Daily Adherence to Schedule	We usually complete our daily schedule as planned.	Pont et al. (2008); Cua et al. (2001); Bortolotti et al. (2015); Khanchanapong et al. (2014)
15	Small Lot Size Production	We have a small amount of work-in-process inventory.	Panizzolo et al. (2012); Zhou (2012); Rahman et al. (2010); Anand and Kodali (2009)
16	Plant Layout and Equipment Layout for Continuous Flow	The layout of the shop floor facilitates low inventories and fast throughput.	Pont et al.(2008); Bortolotti et al. (2015); Mackelprang and Nair (2010). Taj and Morosan (2011) Upadhye et al. (2013)
17	Continuous Improvement/Kaizen	We emphasize the continuous improvement of product quality in all work processes.	Gyampah and Gargeya.(2001); Zhou (2012); Roy (2011); Upadhye et al.(2013); Kumar et al. (2006)
18	Customer Care	We have an effective process for resolving customers' complaints.	Khanchanapong et al. (2014)
19	Customer Involvement	Customer needs and expectations are effectively disseminated and understood throughout the workforce.	Panizzolo et al. (2012); Khanchanapong et al., (2014)

Explanation of these constructs and the description of the lean practices representing the constructs are given in the following paragraphs

1 Workplace Organisation or 5S.

5S refers to the 'industrial housekeeping which enables orderly and clean management of items for ensuring immediate retrieval to sustain a productive work environment (MSME 2013; Devadasan et al., 2012). It is the fundamental and the least complex lean tool which is the first step towards lean thinking. ‘5S’ is a group of five individual practices under mentioned as “Sort, Straighten, Scrub, Stabilize and sustain”. Putting tools and fixtures in their proper place is the essential step in this practice.

This practice helps to reduce the waste that caused by the poorly organised workplace. These waste includes wasting of human time or machine time due to looking for a tool or accessories due to the unorganised workplace. This practice, in general, can be used for accomplishing continuous quality improvement, continuous productivity improvement and cycle time reduction by managing the workspace and workflow, by eliminating waste and reducing process inefficiencies.

2 Standard Operating Procedure (SOP)

SOP refers to the “use of stable, repeatable methods everywhere to maintain the predictability, regular timing and regular output of the process”(Devadasan et al., 2012). SOP provides the base of pull flow and performs as the primary input for quality. In LM, SOP has several elements such as standard work sequence, standard timing, and standard in process inventory, etc. The standard work sequence provides the order in which a worker must perform a task, to minimise variations and thereby minimise defects. Standard timing offers the timing conditions to manufacture the products, balancing with takt time. Standard in–process inventory gives the minimum units of materials undergoing processing which is required to keep a cell or workplace (Sarkar, 2013). The instructions to make use of these documented processes are shared and communicated to the workforce.

3 Setup Time Reduction

Setup time is the nonproduction time due to changes in tool, workpiece, or machine from one to another. Setup time reduction practice helps to reduce, simplify, and or eliminate the work required in changing over machine setup from one item to the next (MSME, 2013). Single Minute Exchange of Die (SMED) is helpful in eliminating the delay while loading the part into the machine or any other facilities (Devadasan et al., 2012). This practice removes one of the wastes, namely delays in manufacturing while producing the products in low volume.

4 Total Productive Maintenance (TPM)

The concept of TPM targets to maximise the overall effectiveness of production equipment. It is a plant improvement methodology, which enables continuous and rapid improvement of the manufacturing processes by preventing its deterioration and malfunctioning by the regular maintenance of machines (Ho, 2002). The workers are encouraged for routine maintenance of equipment including initial cleaning and lubrication. This action will free up the technicians or maintenance team to find the causes of breakdowns and to prevent the similar problems in the future to target to zero failures (Nakajimi, 1988; Pieterse, 2005).

5 Small Group Problem Solving (SGPS)

Solving problems in manufacturing plants are often limited to the removal of the symptoms. The root causes are not identified and rectified, and hence, the problems re-occur. LM promotes the solving the equipment related problems through small group sessions or Quality Circles (QC) (Upadhye et al., 2013). SGPS is a method for team problem-solving by searching for the causes and eliminating them. SGPS include the steps such as setting a target, problem analysis, invent solutions, analyse and interpret the data, execute the solutions, check if it works and standardisations of the solutions and thus the prevention of recurrence of the problem (Challis et al. 2005; Matsui, 2007; Bortolotti 2015).

6 Preventive/ Predictive Maintenance

The practice of monitoring the condition of equipment and maintaining actions accordingly refers to predictive maintenance. The vibration, noise, temperature and the lubricants in critical machines are checked in frequent intervals and chances of failures are identified in advance. Maintenance is planned to avoid such a failure. Predictive maintenance helps to improve the availability of machines and equipment.

7 Kanban (Pull System)

Kanban or pull system is a tool that helps to regulate the flow of goods inside the plant, with the suppliers and customers. It controls the quantity, item and time of production process. In this process, automated replacement of products is made possible with a set of cards that signals when more products are required. It controls the movement of resources in a manufacturing process by replenishing just what has been utilised (Prasad et al., 2016).

8 Just in Time Purchasing

JIT is one of the most familiar lean manufacturing tools. The JIT purchasing concept refers to the ability of a manufacturing facility to order and receive whatever they need and when they need it. For the use of this tool, the on-time delivery by suppliers should be dependable for the manufactures. The basic premise refers to the idea of creating and purchasing items only as they are necessary, to eliminate various types of wastes associated with the purchasing process.

9 Supplier Relationship

Maintaining good relationship with suppliers is one of the prerequisites for the lean success. Building close, long-term relationships with the suppliers helps to improve timely availability of the materials and inventory reduction increasing profitability. Supplier Relationship Management (SRM) and TQM integration helps firms, to achieve environmental performance (Dubey et al., 2014).

10 Early Information Exchange with Suppliers

The interference in the activities of the suppliers such as quality and inventory control and on time delivery of the suppliers are the features of this practice. This practice brings high levels of information transparency or information sharing with suppliers. In advance, the forecasted demand by the firm is shared with the suppliers and which will help the suppliers to plan their production activities and to supply the goods on time.

11 Self Directed Work Teams (SDWT)

SDWT builds an entire group of employees working in the firm, with different skills and talents capable of functioning without the general intensive managerial supervision to achieve the targets or goals of the company. In SDWT has somewhere between two to 25 members and in optimum conditions between five and nine members. In this practice, individual team members have the variety of skills, share functionally interconnected jobs and are together responsible for the final products and team performance (Wall et al., 1986). This practice is helping the firms to empower workers to react to immediate needs without waiting for formal orders from the top and thus eliminate the wastage such as waiting and delay in emergency situations (Axelrod, 2000).

12 Team Work

Teamwork refers to joint and shared work (Olivella et al., 2008). The practice of teamwork makes sure that the small groups work efficiently, on all activities of the firm, including decision making, maintenance and incremental improvements in each area (Bhasin, 2012). The expression "lean work team" is used to denote teams with characteristics including task rotation, self-quality control, and standardization (Olivella, et al., 2008; Holbeche, 1998., Bidanda et al., 2005). In this practice, during problem-solving sessions, opinions and ideas of all team members are collected with all respects before making a decision.

13 Customer Focus

This practice is aimed at the satisfied customers by meeting the customer needs at the maximum level (Demeter and Matyuszin, 2011). In this practice, highest importance is given to customer by systematically and regularly measuring the customer satisfaction through the frequent contact with customers. Under this practice, everyone in the industry considers that satisfying their customers is the primary responsibility of him or her.

14 Daily Adherence to Schedule.

This practice allows the firm to deliver customer value through proper support and leadership from the employees. The daily schedule is fixed as reasonable to complete on time and emphasis to complete as planned as on a daily basis (Cua et al., 2001; Shaw and ward, 2003; Pont et al., 2008). This practice helps to avoid over or under production against scheduled targets, and thus service and order delivery performance of the firm is improved. This practice brings specific continuous improvement programs to decrease the variance in production.

15 Small Lot Size Production

Small lot production ideally one piece is the main element of different LM approaches (Panizzolo et al., 2012). Lot size directly affects inventory and scheduling (Burcher et al. 1996; Lee, 1996). Other effects are less obvious, but equally important. Small lots reduce variability in the system and keep improving smooth production (Pont et al. 2008). This practice reduces work in process inventory to a small amount and encourages continuous improvement.

16 Plant Layout and Equipment Layout for Continuous Flow

Proper plant layout designs help to reduce the material flow distance and material handling costs. The productivity of the manufacturing industries can be increased if good plant layout designs are adopted. Material handling and transportation, continuous flow, reduced WIP, manufacturing flexibility, utilisation of multifunctional workforce are the important criteria in layout design. The layout of the shop floor facilitates low inventories and fast throughput in the manufacturing space.

17 Continuous Improvement/Kaizen

Kaizen is the practice, continuously attempts to make regular, incremental achievements in the manufacturing process to improve efficiency, quality, productivity, safety and workplace culture through employee involvement without much investment (Marksberry et al., 2010; Aken et al., 2010). This process eliminates waste from the production process by combining the collective talents available at the firm to continuously improve the performances (Smadi, 2009, Devadasan et al., 2012). Kaizen promotes continuous questioning of all activities of operation and identification of solutions or alternatives to problems with the help of workforce involvement. During this activity, the people are motivated to contribute their suggestions by reward for their effective suggestions, which are making improvements (Mekong Capital, 2004). These individual improvements may be small but provide great enhancement of the operations.

18 Customer Care

The manufacturing process in a pull system commences from the customer order (Ahlstrom, 1998).. Lean manufacturing concentrates on the customer-defined value to eliminate/ remove the waste what customers do not value. 'Voice of the customer' also helps the company look at its products and services through the eyes of its customers. The customer's complaints are timely resolved through effective customer care practices.

19 Customer Involvement

In this practice, the firm maintains a close relationship with customers and provide them with a secure channel for communicating with them. The company seeks feedback from the customer on quality and delivery performance. The customer needs, and expectations are disseminated efficiently and informed throughout the workforce. As customer's preferences taken into consideration, the management and employees involve more in quality and operations improvement and thus the company can perform well in their operations (Cole et al., 1993).

3.4.2 VARIABLES OF SUSTAINABILITY PERFORMANCE

Sustainable manufacturing strategies affect the environmental, social and economic performance of the manufacturing firms (Dubey et al., 2015; Garbie, 2014). From the analyses by Wang et al. (2015) and Thomas et al. (2012), confirmed the effects of lean towards the three dimensions of sustainability. The literature on the performance measures of lean manufacturing in MSMEs and the sustainable practices are examined to identify the sustainability performance measures of LMPs. Table 3.2 gives the sustainable performance measurements selected for this study based on literature, to evaluate the influence of various lean practices on the sustainable development of the MSMEs.

Table 3.2 Sustainability Performance Variables.

Sl No	***Sustainability Performances***	***Source***
1	Growth in Market Value	Urban and Naidoo (2012); Thomas et al. (2012)
2	Growth in Profit	Urban and Naidoo (2012); Koho et al. (2015)
3	Labour Relationship	Amrina and Vilsi (2015)
4	Low Operational Cost	Zhu et al. (2008); Azevedo et al. (2012); Wang et al. (2015; Zhu et al. (2008)
5	Reduction in Environmental Business Wastage	Wang et al. (2015); Azevedo et al. (2012); Zhu et al. (2008)
6	Reduction in Emission /unit of Production	Koho et al. (2015); Mani et al. (2014).
7	Reduction in Energy/ Fuel usage	Koho et al. (2015); Ball (2015); Veleva and Ellenbecker (2001); Mani et al. (2014)
8	Reduction in Material Usage/ Output	Koho et al. (2015); Goodland (1995); Fliedner (2008)
9	Reduction in Rate of Consumer Complaints	Veleva and Ellenbecker (2001); Wang et al. (2015); Panizzolo et al. (2012)
10	Safety and Health	Wang et al. (2015); Lozano and Huishingh (2011); Longoni et al. (2013).
11	Training and Education	Amrina and Vilsi (2015)
12	Technology Improvement	Fliedner (2008)

The following paragraphs give the details of the sustainability performance measures and its descriptions mentioned in Table 3.2.

1 Growth in Market Value

This is the performance measure indicates the degree of achievement of the market valued outcomes of the organisation (Narasimhan and Kim, 2002; Menor et al. 2007; Urban and Naidoo, 2012). This includes the sales increase and market growth of the firm.

2 Growth in Profit

This represents the financial earnings of the firm. As per the '3P' concept, sustainability has three components, namely people, planet and profit (Gunasekaran and Spalanzani, 2012). Growth in profit is the economic base towards achieving the sustainable growth.

3 Labour Relationship

This is the measure of employee and employer mutual satisfaction and inclusion. The rewards and work environment with the mutual recognition by the employees and employers will provide an effective labour management relationship (Hasle et al., 2011; Godard, 2001).

4 Low Operational Cost

This performance measure is achieved by reducing the operational cost by saving materials and energy and increasing the production efficiency in short-term business operations (Koho et al., 2015; Azevedo et al., 2012; Lozano and Huishingh, 2011). This is considered the important motivational element to organise sustainable business practices (Azevedo et al., 2012; Zhu et al., 2008). The lean implementation makes it possible to reduce the use of resources and to improve the efficiency and thus leads to the reduction in operational cost (Rao and Holt, 2005; Habidin et al., 2013).

5 Reduction in Environmental Business Wastage

This is the measure of reduction in any activities which create harmful effects to the environment and do not create any value for stakeholders in the long term. This performance level provides an evaluation of environmental performance indicating the degree to which the firm progresses concerning its environmental responsibilities (Yang et al., 2011; Montabon et al., 2007)

6 Reduction in Emission/unit of Product

This is an achievement for the companies to reduce the pollutants and harmful emissions (gas, liquid, solid and VOCs) and the discharge of the same. Reduction in product shipment volumes, unnecessary movements and transportation and workplace organisation etc. are helpful to attain this performance (King and Lenox, 2001; Rothenberg et al., 2001; Hong et al., 2012)

7 Reduction in Energy/ Fuel usage

This performance measure is an indication of energy efficiency by reducing the various forms of energy wastages (King and Lenox, 2001; Mani et al., 2014). This includes reduction of energy in forms of heat, noise, radiation, into the environment that may cause direct or indirect harm to the environment.

8 Reduction in Material Usage / Output

This is a performance measure for which the firm has to reduce the material usage, which is directly or indirectly required for the manufacturing process. The reductions in lean wastes such as reduction in defects, over processing and over inventory are the base for improving this performance.

9 Reduction in Rate of Consumer Complaints

This is a measure of the level of consumer satisfaction, which indicates the quality and safety of goods offer to society by the firm (Jayaraman et al., 2012). This performance indicates the level of meeting the social responsibility by the firm through their products (Panizzolo et al., 2012)

10 Safety and Health

. By this measure, continuous improvement of the living environment of their employees and health and safety at work are ensured. Reduced accident levels and workplace injuries are the indicators of this performance (Longoni et al., 2013)

11 Training and Education

This performance measure is the indication of employee education and skill development. The existence of the self-directed, motivated and multi-skilled employee development through the employee empowerment is an indication of the commitment for human capital investment

12 Technology Improvement

This is the indication of the capacity of the perspective of organisations to use existing knowledge, tools or techniques for the efficient management of the system. It is the ability of the firm to control and adapt new technologies (Nasab et al., 2013). The firm's commitment to uplifting scientific and technological growth helps to add the improvements to the organization (Lozano and Huishingh, 2011).

3.4.3 VARIABLES OF AREAS OF LINKAGE BETWEEN LEAN AND SUSTAINABILITY

LM has been concentrating on the elimination of seven deadly wastes (Womack and Jones, 1996) from the manufacturing system. LM aims the optimum use of resources by reducing material, energy, and space and time requirements for producing an output which does not cause harmful effects (Florida, 1996). While referring to the most of the literature, it may get mislead that lean and sustainability concepts have common views only in the perspective of waste reduction and environmental management. However, in addition to environmental and waste reduction scopes, recent researchers have defined some additional scopes of integration of lean and sustainability (Oyedolapo et al, 2013; Piercy and Rich, 2015; Azevedo et al, 2012; Wang et al, 2015; Rothenberg et al, 2001; Cudney et al, 2015). By the close examination of these studies, some more possibilities of integration of lean actions on sustainability may be observed. Table 3.3 provides the 16 areas of linkages, between lean and sustainability, identified from the literature reviewed with the supporting references. These linkage areas are assumed as critical for MSMEs, for the research work. The relative importance of these areas of both lean and sustainability is inconclusive to the industrial world.

Table 3.3 Areas of Linkage Between Lean and Sustainability- Variables.

Sl.No	**Areas of Linkage between lean and sustainability**	**Source**
1	Better Quality	Azevedo et al. (2012); Piercy and Rich (2015)
2	Community Strategy	Piercy and Rich (2015); Azevedo et al. (2012); Lee and Shin, (2010)
3	Continuous Improvement	Longoni et al. (2013); Wang et al. (2015)
4	Cost Reduction	Azevedo et al. (2012); John and Davies (2012)
5	Energy Minimization	Azevedo et al. (2015); Koho et al. (2015)
6	Environment Management	Mollenkopf et al. (2010); Yang et al. (2011)
7	Governance	Azevedo et al. (2012); Piercy and Rich (2015); Park and Linich (2008)
8	Health and Safety Management	Cudney et al. (2015); Wang et al. (2015)
9	Optimum Design	Oyedolapo et al. (2013)
10	Performance Improvement	Azevedo et al. (2012); Oyedolapo et al. (2013)
11	Resource Management	King and Lenox, (2001); Rothenberg et al. (2001)
12	Supply Chain Management	Azevedo et al. (2012); So and Sun (2015) Martínez-Jurado and Moyano-Fuentes (2014)
13	Transparency	Piercy and Rich (2015); Ciasullo and Troisi (2013)
14	Value Maximization	Oyedolapo et al. (2013); Ciasullo and Troisi (2013)
15	Waste Reduction	Cabral et al. (2012); Piercy and Rich (2015)
16	Worker Empowerment	Jain and Malik .(2013); Piercy and Rich (2015); Amrina and Vilsi (2015)

1 Better Quality

Quality improvement of the products and processes are the most common target of lean and sustainable manufacturing. The elimination of defects reduces rework, and scrap. Improving the quality leads to economic and environmental benefits (Simpson and Power, 2005; Rothenberg et al., 2001). The lean production operations have a clear overlap with sustainability in the space of quality (Piercy and Rich, 2015).

2 Community Strategy

The lean practices have a positive impact on the organisation and the community in which the firm functions through the contributions of positively supporting the various stakeholders from the society (Piercy and Rich, 2015; Lee and Shin, 2010). Preservation of optimistic status in the community is a possible integration between the lean policies and sustainability.

3 Continuous Improvement

Sustainability involves "continuous improvement process that involves managing processes in such a way that the environment will continue to support future activities as it presently does" and has the positive linkage between LM (Ehrenfeld, 2008). Kaizen or continuous improvement is one of the basic principles of lean approach, which integrates with the sustainability principles.

4 Cost Reduction

As the economic aspects are common in both sustainability and lean, both these principles are contributing to cost reduction (Azevedo et al., 2012; John and Davies., 2012). Also, a cost incurred for the firm to rectify a negative effect causes an increase in the associated implementation cost in lean or the cost of operating in a sustainable manner (Oyedolapo et al. 2013).

5 Energy Minimization

The lean principles, which help to generate the same output with fewer resources, and energy, are naturally good for the environment and for reducing the cost of operation for the company (Florida, 1996). Hence, lean principles can be integrated with the economic and environmental sustainability towards the energy minimisation of the energy consumption.

6 Environment Management

Addressing the environmental improvements or issues is considered as one of the core objectives of integrating lean and sustainability (Corbett and Klassen, 2006; Piercy and Rich, 2015). The goal of generating the same outcome with fewer resources is the environmentally friendly approach of lean. The practices lead to the environmental aspects of sustainability is the supplementary benefits of lean philosophy and operations (Oyedolapo et al., 2013; Corbett and Klassen, 2006).

7 Governance

This refers to the issues related to the management activities such as socially responsible investment, written policies, relations with clients, investors, local communities, other stakeholders and environment (Ciasullo and Troisi, 2013; Piercy and Rich, 2015; Park and Linich, 2008). Sustainability principles and value creation are the intrinsic part of SMEs, which on the one hand, the centrality of ethical governance (Ciasullo and Troisi, 2013). Transparency supports the internal governance and strengthens sustainability (Piercy and Rich, 2015). At the same time, a lean organisation through its practices, namely, SOPs, effective communication channels with workers, suppliers and customers promotes transparency and governance (Piercy and Rich, 2015).

8 Health and Safety Management

The studies reveal that workplace practices lead to reduced accidents and better safety to the employees. The social element of sustainability focused on the people has a vision of safe and clean workplace. The concepts of lean and sustainability can move together toward a safe and healthy work environment (Franchetti et al. 2009; Sroufe, 2003).

9 Optimum Design

Implementation of lean principles facilitates the prospects to redesign the layout, facilities, supplier selection, effective materials and address closed - loop issues at the design stage (Farish, 2009; Florida, 1996). This attitude change and operational change of lean philosophy offers a greater opening for integrating to sustainability aspects through environmental issues (Hughes, 2012)

10 Performance Improvement

Performance improvement in various levels is the motivation in lean implementation, leading to increased efficiency. These improvements are caused by the utilisation of resources regarding human power, materials, machines and infrastructure with reduced or zero wastes. Hence, performance improvements assure a given level of stakeholder's satisfaction towards the economic, environmental and social growth.

11 Resource Management

Lean advocates the use of fewer resources for the same value or output. Sustainability at the same time is an increase in productivity and reduction of consumption of resources without compromising product or service quality, competitiveness, or profitability while helping to reduce the harmful effect on the environment. Thus, effective management of the available resources is the common underlying thought of lean and sustainability.

12 Supply Chain Management

Lean strategy gives special attention to the elements of supply chain management by establishing supplier related processes. Building the long-term relationship, and information transparency with suppliers are the key features of lean. The supply chain related lean practices reduce the joint environmental impact of all the firms included in the chain and improve the economic performance (Simpson and Power, 2005; Geffen and Rothenberg, 2000). Both lean and sustainability can integrate into supply chain management in the economic and environmental issues to achieve a wide range of sustainability objectives.

13 Transparency

With the growing demand from stakeholders, companies are moving towards more transparency in their economic, environmental and social governance. These sustainability issues can be underpinned by the transparency of information within the firm boundaries. The lean practices in a firm are providing this openness (Lamming, 1993) which supports a reduction in wastage at the firm boundary by pooling the resources which are needed into the firm (Corbett and Klassen, 2006; Kainuma and Tawara, 2006).

14 Value Maximisation

Lean practices aim to optimise the flow of products and services through the entire value stream by decreasing waste and increasing efficiency throughout the whole value chain. According to Ciasullo and Troisi (2013), sustainability principles are an intrinsic part of the SME value creation process, especially the entrepreneurial values (Jenkins, 2009).

15 Waste Reduction

Sustainability constitutes three basic dimensions and waste management is one of the major requirements and challenges to achieve these dimensions (Wang et al., 2015). The basic principle of lean is developed from the elimination of non-value added activities (Hajmohammad et al., 2013). The waste reduction is the traditional area of integration of both the concepts.

16 Worker Empowerment

A well-trained and empowered workforce is one of the basic requirements of the lean processes (Taubitz, 2010). Higher levels of safety, output, and quality and standardised work are the result of this empowerment. The positive outcomes in three dimension of sustainability performance results a sustainable working environment (Taubitz, 2010, Piercy and rich, 2015).

3.5 QUESTIONNAIRE DEVELOPMENT

This research has its base on the thorough literature review in the area of the research, as mentioned in the previous sections. The preliminary hypotheses are formed from the knowledge gained from the literature review. Initially, a draft questionnaire was developed based on the hypotheses formulated, from the light of the information from the literature review as suggested by Collis and Hussy (2009) and Saunders et al. (2009)

The questionnaire has four sections. The first part of the questionnaire consists of general information about the company and that of the respondents. This part includes questions related to the name of the firm, size of the company, type of manufacturing process, type of production system, level of investment and other relevant details of the firm. The objective of this section is to check the suitability of the firm to include in the analysis of the study. The operational management system variables (grouping variables) for the analysis are obtained from the responses for this section.

The second section consists of the questions related to the level of adoption of lean manufacturing practices in the concerned firms. The respondents are requested to rate their level of agreement based on the statements given as numbered questions which were identified as the measures of variables of the construct (Table 3.1) of the lean manufacturing practices. All the variables are rated on a five-point 'Likert scale' from "strongly disagree" (1) to "strongly agree" (5).

The third part of the questionnaire consists of questions to measure the sustainability performances of the firms. The respondents are requested to rate their firm's performance compared to their primary competitors during the last three years, on a five-point Likert scale from "much worse"(1) to "much better"(5). Total of 12 performance measures from the Table 3.2 is listed as numbered questions in the questionnaire. The fourth part of the questionnaire is to get the areas of linkage between lean and sustainability relevant to the firm of the respondent. The identified areas from the Table 3.3 are listed as separate numbered questions. The respondents are requested to respond to each area on a 5-point Likert scale, whether they strongly disagree (1) to strongly agree (5) as an important area of linkage between lean and sustainability related to their firm.

The ‘five-point Likert scale’ was selected in this work due to the following reasons. Questionnaires rated with five-point Likert scale are simple to answer and not confusing (Delvin et al., 1993; Hayes, 1992). This quality of five-point scale increases the response rate, response quality and reduces the respondents’ frustration level compared to the other variations of the Likert scale (Sachdev and Verma, 2004; Dawes, 2008). Evidence shows that five-point Likert scale was widely approved and used by the various prior researchers in the subject area of this work (Zhu et al., 2008; Khanchanapong et al., 2014; Ganapathy et al., 2014; Mitra and Datta, 2014; Chavez et al., 2015; Thanki and Thakkar, 2014).

3.6 PRE TESTING AND PILOT SURVEY

Content validity of the draft questionnaire was assured by pretesting with a panel of experts. This panel was included three groups of experts with academicians in university, research scholars, and industry practitioners, having substantial knowledge in the area of lean and sustainability. Incorporating their suggestions, the sequence, and the wordings of questions and layout of the questionnaire were modified.

After this, a pilot survey was conducted with 30 members from the randomly selected respondents from the targeted population as suggested by Perneger et al. (2015). Based on their feedback, two questions in the draft questionnaire were modified. For instance, respondents suggested the term ‘set-up time reduction’ and ‘information transparency’ in two of the questions related to LMPs were required more clarity to avoid confusion. Accordingly, the explanation ‘time required to prepare or refit equipment and workstations’ was added to the term ‘setup time reduction’ and the words ‘information sharing’ to the term ‘information transparency. Based on this pretesting and pilot survey results, incorporating the suggestions and feedback from the respondents, the final print of the questionnaire was taken. The final questionnaire used for this research work is shown in Appendix.1.

3.7 SAMPLE DESIGN

A sample design is a part of the target population, carefully selected to represent that population. As the present study focused on performances of MSMEs only, the sample design population includes firms under the classification of MSMEs. For this particular work, whole MSMEs in the manufacturing category in Kerala, India were selected as the population. The population database was collected by contacting the authorities of "Association of Small And Medium Enterprises" (ASMEs) in various industrial areas and the District Industries Centres (DICs) in the different district of the state. The database includes the SMEs located in the tropical regions of the industrial parks, special economic zones, various industrial clusters formed by the Government of Kerala as well as other industries situated outside this specified industrial sector within the state.

3.8 SAMPLE SELECTION AND DATA COLLECTION

A sample of 500 manufacturing MSMEs was randomly chosen from the total population collected from Directories of the ASMEs and DICs of Kerala state. The procedure adopted in the present study is simple random sampling from the probability sampling methods. Under this sampling design, every item of the frame has an equal chance of inclusion in this sample. This sample includes the representation of the MSMEs from the various districts of the Kerala state. The questionnaire (Appendix 1) was mailed and personally distributed to these industries together with a covering letter (Appendix 2). A copy of the letters of recommendations from the Honourable Director of Kerala state industries department (Appendix 3) was also attached. This recommendation letters have expressed the purpose and importance of the research together with the request for sharing the required information with the researcher. In the covering letter, the respondents have been assured that the information would be kept in strict confidence and individual data would not be published anywhere.

Through the rigorous follow-up, within in a period of six months between December 2015 to May 2016, 252 numbers of usable responses were received with a response rate of 50.4%.

3.9 RESPONSE RATE

According to authors, the minimum required response rate of an empirical operations management research is 20 percent (Malhotra and Grover, 1998; O'Leary-Kelly and Vokurka, 1998). A study conducted by Baruch and Holtom (2008), analysing 1,607 studies published in 17 referred journals, examined an average response rate of 35.7 percent of organisations with a standard deviation of 18.8. A low response rate is common in research surveys in which respondents are SME owners or managers (Gadenne et al., 2009). So the response rate of 50.4 percent of this study can be considered as very sufficient for statistical analysis and drawing inferences.

3.10 TOOLS AND TECHNIQUES

The statistical software package of the IBM Statistical Package for Social Science version 20.0 (SPSS 20.0) was used for the data analysis. Initially, the collected data was carefully entered into the data view of SPSS. The preliminary statistical requirements such as normality and linearity were tested using this package. The descriptive analysis, One sample T-test, Kruskal Wallis - Chi-square test, Exploratory Factor Analysis, etc. are the major statistical analysis performed in this work which is presented in chapter 4 and chapter 5.

In the subsequent analysis, in chapter 6, Structural Equation Modeling (SEM) was used to find the structural relationships between the constructs of LMPs and sustainability performance. The software 'AMOS 21 was used for SEM model development and analysing the overall fit of the models. Further, in chapter 7, case study method is used to validate the results derived from the SEM. Five case studies were conducted in selected organisations representing different types of industries across the state of Kerala.

3.11 CONCLUSION

This chapter presents the research model and framework by linking the lean practices and sustainability performance. The model explains how the lean practices transform to sustainable development. The areas of linkage between lean, sustainability and operational management system were incorporated in the framework. Further, the chapter explains the research design and constructs in details. The variables of individual constructs and its measures identified from the literature are explained. Details of the questionnaire development, sample design, data collection and analysis are also described in this chapter.

CHAPTER 4
DESCRIPTIVE STATISTICS

4.1 INTRODUCTION

This chapter gives the results of the descriptive statistics of the variable of lean manufacturing practices and sustainability performance of the MSMEs, by analysing the data from the questionnaire survey. The questionnaire used for the data collection has 19 variables related to LMPs, 12 variables related to sustainability performances and 16 items related to the areas of linkage between lean and sustainability. The responses were collected on a '5 point Likert scale'. Descriptive statistics was carried out by calculating the mean and standard deviations of responses of variables.

4.2 DESCRIPTIVE STATISTICS OF LMPS

Over the 19 variables related to LMPs, the respondents were requested to respond whether they are agreeing with the respective statements representing variables with respect to their firm. The statements representing the LMPs are given in the Table 3.1. The mean and standard deviations are calculated for each variable concerning the responses obtained in the given scale. Table 4.1 gives the variable code, statement of variables, calculated mean and standard deviation and the rank of the variables based on the mean values. Table 4.1 also indicates the level of acceptance of these practices in the MSME firms.

The responses were collected on a five-point Likert scale,ranging from 1 to 5. The middle point of the scale 3.0 indicates the respondents neither agree nor disagree with the use of the particular lean practice in their firm. The higher values indicate a higher-level adoption of these practices. The results show that the mean value of the lean practices ranges from 2.079 to 4.262 and the standard deviation from 0.7952 to 1.3498. It can be observed that the mean values of the responses of all individual practices are higher than 3.0, except for two practices indicates that lean practices and principles are followed by the firms to a good extent.

Table 4.1 Descriptive Analysis of Lean Practices

Variable Code	Variable	Mean	Standard Deviation	Rank
LMP01	Our plant emphasise putting all tools and fixtures in their proper place	3.952	0.8869	5
LMP02	We use standardized and documented processes which are well instructed to our employees	3.897	1.0125	6
LMP03	We focus to reduce process set up time -- the time required to prepare or refit equipment, workstations etc.	3.544	1.1613	12
LMP04	Workers carry out routine maintenance on all equipment (e.g., Cleaning, lubrication or small repairs) following standard procedures	3.845	1.1689	7
LMP05	Many equipment problems have been solved through small group sessions	3.202	1.2380	17
LMP06	Our plant following either preventive/predictive maintenance	3.706	1.2178	11
LMP07	We use Kanban pull system (or containers of signals) for production control	2.079	1.0976	19
LMP08	We can depend on time delivery of our suppliers	3.984	0.8925	3
LMP09	We have built close, long-term relationships with our suppliers	4.262	0.7952	1
LMP10	We have high levels of information transparency or information sharing with our suppliers	3.841	0.9607	8
LMP11	We form teams capable to do their daily work without formal leadership.	3.294	1.2405	16
LMP12	During problem-solving sessions, we make an effort to get all team members' opinions and ideas before making a decision	3.353	1.2134	14
LMP13	We systematically and regularly measure customer satisfaction	3.984	1.0636	4
LMP14	We usually complete our daily schedule as planned	3.782	1.0543	10
LMP15	We have a small amount of work-in-process inventory	3.437	1.0932	13
LMP16	The layout of the shop floor facilitates low inventories and fast throughput	3.341	1.0871	15
LMP17	We emphasise the continuous improvement of product quality in all work processes	2.897	1.3498	18
LMP18	We have an effective process for resolving customers' complaints	4.135	0.9685	2
LMP19	Customer needs and expectations are effectively disseminated and understood throughout the workforce	3.813	1.0790	9

From the Table 4.1, it can be stated that the two items were the most used lean practices which having mean values more than 4.0. The items included in this list are maintaining ‘long-term supplier relationship’ (LMP09) and ‘customer care’ by an efficient process for resolving customer complaint (LMP18). Depending on time delivery of suppliers (LMP08), systematically and regularly measure of customer satisfaction (LMP13) and process management by emphasising to put all tools and fixtures in the proper place (LMP01) are the practices having the mean values near to 4.0. The two practices, which have mean values less than 3.0, are Kanban pull system (LMP07) and continuous improvement (LMP17).

The findings of this analysis are comparable with similar studies. The results are related to studies by Pannizzolo et al. (2012) in Indian SMEs and by Filho et al. (2016) in Brazilian SMEs except for some findings as the key suppliers delivering to the plant on a just-in-time basis are very rarely used by the SMEs. The results show that MSMEs in the sample frame are following and practising the most of the LMPs.

4.3 DESCRIPTIVE STATISTICS OF SUSTAINABILITY PERFORMANCE

The mean and standard deviation of the responses to the sustainability performance of the firms obtained on a five-point Likert scale on 'much worse' (1) to 'much better' (5) are calculated and tabulated in Table 4.2. The respondents were requested to record their performances measured in comparison with their primary competitors in the last three years. The mean value of the sustainability performances ranges from 3.413 to 4.234 and standard deviation 0.7229 to 1.0593.

From the Table 4.2, labour relationship (SP09), safety and health (SP08), and decreases in the rate of customer complaints (SP11) are the more important sustainability performances from lean practices as the mean values are greater than 4.0. This result is the clear indication of the social relevance of lean practices in sustainability benefits. Technology improvement (SP12), growth in market value (SP02) and reduction in emission/unit of production (SP05) are the sustainability performances in the next three positions.

Table 4.2 Descriptive Analysis of Sustainability Performances of Lean

Variable Code	Sustainability Benefits of lean	Min	Max	Mean	Std. Deviation	Rank
SP01	Low Operational cost	1.0	5.0	3.413	1.0002	12
SP02	Growth in Market Value	1.0	5.0	3.738	0.9292	5
SP03	Growth in Profit	1.0	5.0	3.504	0.9510	10
SP04	Reduction Business wastage	1.0	5.0	3.627	0.8992	8
SP05	Reduction in Emission /unit of Production	1.0	5.0	3.690	0.8465	6
SP06	Reduction in Material Usage/ Output	1.0	5.0	3.460	0.9116	11
SP07	Reduction in Energy/ Fuel usage	1.0	5.0	3.619	0.9047	9
SP08	Safety and health	1.0	5.0	4.004	0.7858	2
SP09	Labour relationship	1.0	5.0	4.234	0.7229	1
SP10	Training and Education	1.0	5.0	3.655	1.0390	7
SP11	Decrease in rate of consumer complaints	1.0	5.0	4.000	0.9015	3
SP12	Technology Improvement	1.0	5.0	3.885	1.0593	4

Reduction in business wastage (SP04), reduction in emission per unit of production (SP05), and the reduction in material usage per output (SP06) are environmental benefits. Reduction in operational cost (SP01), Growth in market value (SP02) and growth in profit (SP03) are the indication of the economic benefit of lean practices. The least mean value of all the responses is 3.413. This result indicates the general agreement among all the respondents on all the sustainability benefits contributing to the lean practices.

4.4 DESCRIPTIVE STATISTICS OF AREAS OF LINKAGE BETWEEN LEAN AND SUSTAINABILITY

The responses to the sixteen areas of linkages identified between lean and sustainability are tabulated in Table 4.3. The respondents were requested to rate their responses on the five-point Likert scale, whether they strongly disagree (1) to strongly agree (5) about each area of linkage as relevant to their firm.

4.4.1 RANKING THE AREA OF LINKAGE BETWEEN LEAN AND SUSTAINABILITY

The ranking of the attributes by the mean value was used to understand the position of the attributes by the priority given by respondents. The standard deviation is used as a bar if it two attributes came with the same mean, the attribute with lower standard deviation was assigned the highest rank. As per the ranking by the mean value, waste reduction, better quality and health and safety are the most important areas. Continuous improvement, worker empowerment, performance improvement and value maximisation are the next important areas of linkage. Community strategy, governance, and optimum design are the less important areas of linkages

Table 4.3 Ranking of Area of Linkage Between Lean and Sustainability

Areas of Linkage between lean and sustainability	**Sample size**	**Minimum**	**Maximum**	**Mean**	**Std. Deviation**	**Rank**
Waste reduction	252	1.0	5.0	4.167	0.8769	1
Better Quality	252	1.0	5.0	4.063	0.8677	2
Health and Safety Management	252	1.0	5.0	4.048	0.8118	3
Continuous Improvement	252	1.0	5.0	3.921	0.9112	4
Worker Empowerment	252	1.0	5.0	3.913	0.8928	5
Performance Improvement	252	1.0	5.0	3.865	0.8958	6
Value Maximization	252	1.0	5.0	3.833	1.0275	7
Environment Management	252	1.0	5.0	3.706	1.0065	8
Resource Management	252	1.0	5.0	3.579	0.9392	9
Cost Reduction	252	1.0	5.0	3.563	1.0562	10
Supply chain Management	252	1.0	5.0	3.520	1.0195	11
Transparency	252	1.0	5.0	3.496	1.0119	12
Energy Minimization	252	1.0	5.0	3.492	1.1023	13
Community Strategy	252	1.0	5.0	3.262	0.9793	14
Governance	252	1.0	5.0	3.218	1.0730	15
Optimum Design	252	1.0	5.0	2.095	1.1576	16

4.4.2 ONE- SAMPLE T-TEST

One sample t-test was used to test the variation in the sample mean to the hypothesised mean of the attributes representing the area of linkage and the lean sustainability benefits. A hypothesised mean (Uo) of the attributes is fixed at 3.0 as the study used a five-point Likert scale to rate the attributes. This hypothesis implies that the attribute is important when the mean value is above 3.0. The null hypotheses are defined for each attribute, as all attributes are unimportant. This indicates the sample mean of each attribute equal to hypothesised mean value. The alternative hypotheses are defined, as each attribute are important indicates sample means are higher than the hypothesised mean values. A two-tailed significance level of each attribute can be measured using the one sample t-test. Half of this two-tailed p-value gives the p-value for the one tail test, which is the criterion for the significance of the attributes. These tests were conducted at a confidence level of 95 percentages.

One-sample test with a test value equal to 3.0 is conducted as shown in Table 4.4 to identify the significance of each attribute. This two-tailed test shows that all the areas are significant ($p < 0.05$) except the area of 'optimum design' ($p = 0.480$) in the contest of linkage between lean and sustainability. Hence, from further analysis, the attribute 'optimum design' is removed.

Table 4.4 One-sample t-Test for Testing the Significance of the Areas of Linkage Between Lean and Sustainability

Areas of Linkage between Lean and Sustainability	**Test Value = 3.0**					
	t	**df**	**Sig. (2-tailed)**	**Mean Difference**	**95% Confidence Interval of the Difference**	
					Lower	**Upper**
Waste reduction	21.121	251	0.000	1.1667	1.058	1.275
Environment Management	11.141	251	0.000	0.7063	0.581	0.831
Supply chain Management	8.094	251	0.000	0.5198	0.393	0.646
Worker Empowerment	16.228	251	0.000	0.9127	0.802	1.023
Better Quality	19.456	251	0.000	1.0635	0.956	1.171
Health and Safety Management	20.485	251	0.000	1.0476	0.947	1.148
Value Maximization	12.875	251	0.000	0.8333	0.706	0.961
Energy Minimization	7.086	251	0.000	0.4921	0.355	0.629
Resource Management	9.792	251	0.000	0.5794	0.463	0.696
Optimum Design	0.707	251	**0.480**	0.0516	0.092	0.195
Cost Reduction	8.470	251	0.000	0.5635	0.432	0.695
Performance Improvement	15.330	251	0.000	0.8651	0.754	0.976
Transparency	7.782	251	0.000	0.4960	0.370	0.622
Continuous Improvement	16.038	251	0.000	0.9206	0.808	1.034
Community Strategy	4.246	251	0.000	0.2619	0.140	0.383
Governance	3.229	251	0.001	0.2183	0.085	0.351

4.5 OPERATIONAL MANAGEMENT SYSTEM - GROUPING VARIABLES

All the 15 areas of linkage that are identified and found to be significant, may not be relevant to a particular type of industry (Piercy and Rich, 2015). This postulate is true because, the sustainability is influenced by the 'operational management system' variables or grouping variables of the firms (Jayaraman et al., 2012)

This means that, the operational system characteristics of the firm will affect the list of relevant areas of linkages between lean and sustainability of the firm. So when the significance of all the identified areas of linkage between lean and sustainability are considered, there may be statistical differences among the groups of the firms classified based on the operational system characteristics.

The knowledge of whether the different operating system characteristics are affecting or not, the lean sustainability integration will help the policy makers in framing the policies of lean and sustainability for the different groups of MSMEs. For the study reported here, four operational system variables were selected for the analysis. These variables are, (1) level of investment (Micro, Small and Medium), (2) manufacturing sector (Metal, Automotive, Chemical, plastic, etc.), (3) type of manufacturing process (Job shop, flow shop and batch production) and (4) type of production system (make/ assemble to stock or order). The respondents were grouped according to this four grouping variables depending on the operational system. The statistical differences among the various groups of respondents were investigated in the areas of linkages between lean and sustainability. The Kruskal–Wallis Chi-square test helps to examine whether the difference, according to the grouping variables are significant or not. The 'Kruskal–Wallis test' is a non-parametric test to investigate the difference between groups without following normal distribution.

The null hypothesis states that there is no significant difference and alternative hypothesis states that there is a statistical difference, between the groups of respondents' classified based on grouping variables, related to areas of linkages. If significant differences exist, post-hoc tests will be required to determine the nature of these differences.

4.5.1 LEVEL OF INVESTMENT

This classification is based on the level of investment in plant and machinery according to MSMED act 2006. In this classification, firms are categorised into three groups, namely, micro, small and medium firms. The frequency of each category of the firms responded to the survey is shown in Figure 4.1 with a percentage of 13.5, 67.9 and 18.6 % respectively

Figure 4.1 Categorisation Based on the Level of Investment

The Kruskal-Wallis test is conducted to present the statistical difference between the firms with different levels of investment.

Table 4.5 Kruskal-Wallis Test for Statistical Difference Between Firms at Different Levels of Investment

Area of linkage between lean and sustainability	x^2	d f	Asymp.sig
Waste reduction	6.334	2	0.042
Environment Management	17.728	2	0.000
Supply chain Management	33.95	2	0.000
Worker Empowerment	13.276	2	0.010
Better Quality	16.638	2	0.000
Health and Safety Management	16.698	2	0.000
Value Maximization	23.527	2	0.000
Energy Minimization	33.502	2	0.000
Resource Management	27.656	2	0.000
Cost Reduction	24.274	2	0.000
Performance Improvement	17.610	2	0.000
Transparency	18.392	2	0.000
Continuous Improvement	23.366	2	0.000
Community Strategy	15.729	2	0.000
Governance	30.617	2	0.000

Note: Kruskal-Wallis Test based on grouping variable-Level of investment

As evident from Table 4.5, all the variables of areas of linkages giving p-values less than 0.05 while applying Kruskal -Wallis test based on the grouping variable 'level of investment'. As the p-values are < 0.05, null hypothesis are rejected. This result indicates a statistically significant difference among the firms classified according to grouping variable 'the level of investment in all areas of linkage between lean and sustainability

4.5.2 TYPE OF MANUFACTURING PROCESS

The grouping based on the manufacturing process split the responding firm into three categories such as job shop, batch production, and flow shop. The frequency of each category are shown in Figure 4.2. The percentage of the firms responded to the survey under each category are 15.2, 52.9 and 32.9 % respectively.

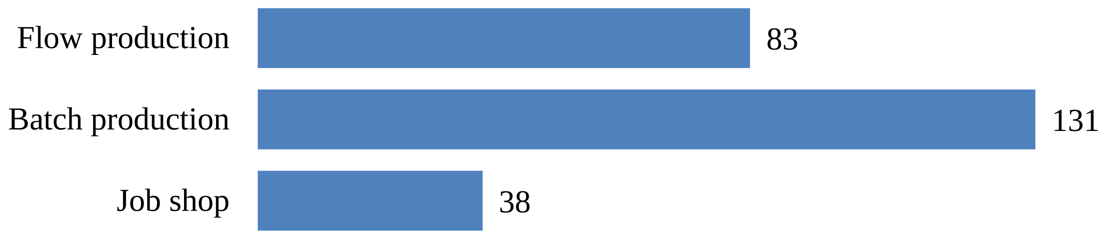

Figure 4.2 Categorisation Based on Types of Manufacturing Process

In Table 4.6, Kruskal-Wallis test was applied to categorise the firms based on this grouping variable. This test confirms that the seven areas of linkages namely waste reduction, environmental management, supply chain management, energy minimisation, resource management, community management and governance having a p-value < 0.05 leads to the rejection of null hypothesis, which indicates a statistically significant difference according to the grouping variable. All other areas, namely worker empowerment, quality, health and safety management, value maximisation, cost reduction, performance improvement, transparency, and continuous improvement, have p-values > 0.05. This result indicates no statistical divergence of the firms classified according to the nature of manufacturing processes in these eight areas of linkages between lean and sustainability.

Table 4. 6 Kruskal-Wallis Test for Statistical Difference Between Job shop, Batch and Flow Production Manufacturing Processes

Area of linkage between lean and sustainability	x^2	df	Asymp. Sig
Waste reduction	11.038	2	0.004
Environment Management	17.167	2	0.000
Supply Chain Management	9.202	2	0.010
Worker Empowerment	4.776	2	0.092
Better Quality	3.918	2	0.141
Health and Safety Management	5.341	2	0.069
Value Maximization	2.279	2	0.320
Energy Minimization	8.501	2	0.014
Resource Management	6.125	2	0.047
Cost Reduction	4.645	2	0.098
Performance Improvement	4.004	2	0.135
Transparency	5.788	2	0.055
Continuous Improvement	2.461	2	0.292
Community Strategy	7.759	2	0.021
Governance	10.224	2	0.006

Note: Kruskal-Wallis Test based on grouping variable: Type of Manufacturing Processes

4.5.3 TYPE OF PRODUCTION SYSTEM

Based on the type of production system, firms are categorised into ‘make to stock’, ‘make to order’, ‘assemble to stock’, and ‘assemble to order’. The frequency of each category is shown in Figure 4.3. The percentage of firms responded to survey under each category are 32.1, 58.7, 3.2 and 6 % respectively.

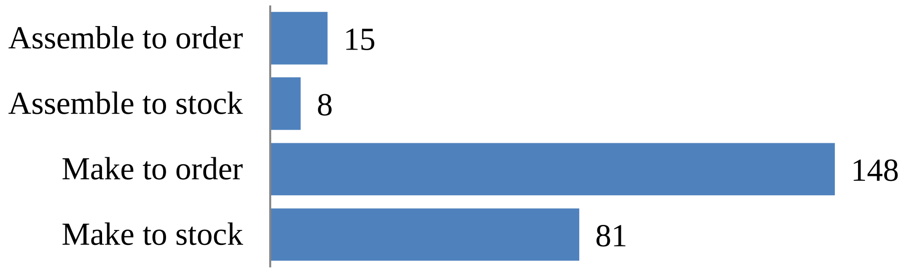

Figure 4.3 Categorisation Based on Type of Production System

Results of the Kruskal Wallis- chi-square test carried out are shown in Table 4.7 to test the statistical divergence of the respondents based on the production systems.

The degree of freedom observed for the test is equal to three. The asymptotic significances of the attributes are found less than 0.05 for the attribute ‘environment management’ and ‘value maximisation'. For all other attributes, the value of asymptotic significance is above 0.05. The asymptotic significance (p-value) is greater than 0.05 indicates null hypothesis cannot be accepted. This implies that there is no statistical divergence among the different production systems in MSMEs except the attributes environmental management and value maximisation.

Table 4.7. Kruskal-Wallis Test for Statistical Difference Between Various Production Systems- Make or Assemble to Stock or Order

Area of linkage	x^2	*df*	*Asymp. Sig*
Waste reduction	2.091	3	0.554
Environment Management	12.721	3	0.005
Supply chain Management	6.113	3	0.106
Worker Empowerment	3.696	3	0.296
Better Quality	0.975	3	0.807
Health and Safety Management	4.48	3	0.214
Value Maximization	8.092	3	0.044
Energy Minimization	3.553	3	0.314
Resource Management	0.846	3	0.839
Cost Reduction	1.994	3	0.574
Performance Improvement	0.159	3	0.984
Transparency	0.942	3	0.815
Continuous Improvement	0.066	3	0.996
Community Strategy	2.352	3	0.503
Governance	3.465	3	0.325

Note: Kruskal-Wallis Test based on grouping variable: Type of production system

4.5.4 TYPE OF MANUFACTURING SECTOR

This grouping is based on the product of the firm. In this classification, manufacturing companies from 10 different sectors, namely automotive/machinery, metal/mechanical, electrical/electronics, food, paper, plastic/polymers, rubber, textiles/ garments, chemical, and wood. The Figure 4.4 gives the bar chart of the frequency of each sector in the study. The percentage of firms responded in each category are 8.7, 18.7, 6.0, 15.1, 3.2, 17.5, 7.9, 2.4, 17.1, 3.6 % respectively.

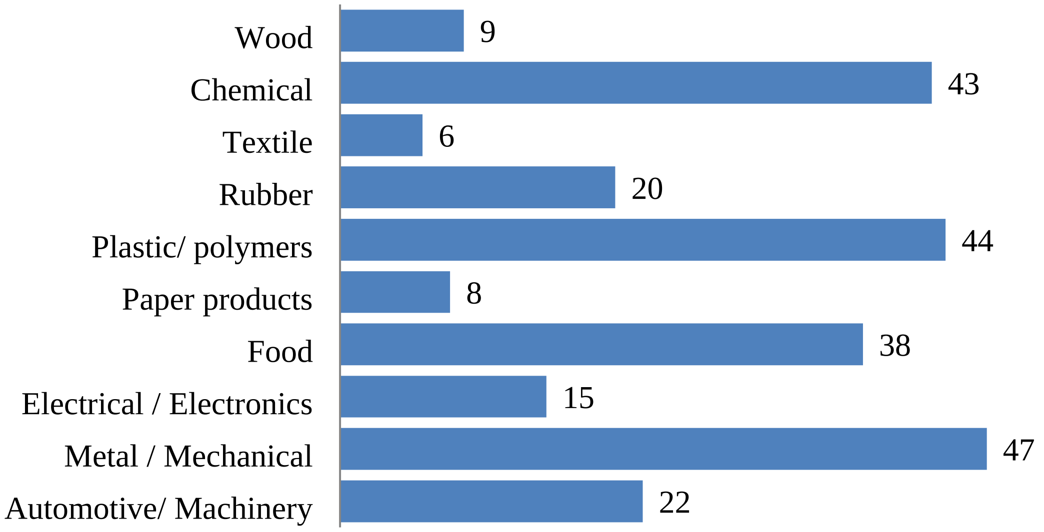

Figure 4.4 Categorisation Based on Manufacturing Sector

. In Table 4.8, the results of the Kruskal-Wallis test applied based on the grouping variable, 'manufacturing sector' is presented.

Table 4.8. Statistical Difference Between Various Manufacturing Sectors.

Area of linkage of lean and sustainability	x^2	df	Asymp. Sig
Waste reduction	8.824	9	0.454
Environment Management	8.01	9	0.533
Supply chain Management	10.346	9	0.322
Worker Empowerment	7.919	9	0.542
Better Quality	12.219	9	0.201
Health and Safety Management	8.469	9	0.488
Value Maximization	5.700	9	0.770
Energy Minimization	8.043	9	0.530
Resource Management	13.807	9	0.129
Cost Reduction	10.081	9	0.344
Performance Improvement	19.405	9	0.022
Transparency	7.473	9	0.588
Continuous Improvement	14.385	9	0.109
Community Strategy	16.156	9	0.064
Governance	12.83	9	0.170

Note: Kruskal-Wallis Test based on grouping vavariable: Type of Manufacturing sector

All the asymptotic significance (P Value) are greater than 0.05 indicates that null hypothesis cannot be accepted. This implies that there is no statistical divergence among the respondents from different manufacturing sectors in the case of areas of linkages between lean and sustainability.

4.6 CONCLUSION

The descriptive statistics of lean practices shows that the mean value of lean manufacturing practices ranges from 2.079 (Kanban pull system) to 4.262 (Long-term supplier relationship). Long-term supplier relationship, customer-focused business and workplace organisation etc. are the mostly used lean practices. The outcome of the analysis hints that the LMPs are convincingly followed in Indian MSMEs.

The descriptive analysis of sustainability performance indicates that the ‘labour relationship’, ‘health and safety’ and ‘decrease in the rate of customer complaints’ are three important benefits of synchronising lean and sustainability. This result is the clear indication of the social relevance of lean practices in sustainability aspects. The respondents have agreed to all the benefits listed in the study, which is evident from the least mean value of all benefits being 3.143.

The study shows that waste reduction is the most important area of linkage between lean and sustainability. All forms of wastes are non-value added activities, which will affect the economic and environmental sustainability of the firms. Quality and safety are other important area of linkage between the lean and sustainability. All the listed areas of linkage except the optimum design are important, as the least mean value of the attributes obtained is 3.218. This result is a clear and reliable indication of synergies of lean and sustainability in manufacturing MSMEs.

The non-parametric Kruskal Wallis test was used to investigate the effect of four grouping variables in the areas of linkages between lean and sustainability. The Kruskal-Wallis test shows that a significant difference exists among the respondents classified according to the level of investment in plant and machinery in the area of linkage between lean and sustainability. These findings indicate the necessity of detailed study of linkages between lean and sustainability independently in different investment levels.

The Kruskal-Wallis test based on the grouping variable, ‘type of manufacturing process’, shows that no statistically significant difference exist among the respondents of the job, batch and flow production processes in more than 50 percent of the listed area of linkage between lean and sustainability. Similarly, test results imply that there is no statistical difference between the respondents from different production systems except the attribute ‘environmental management’ and ‘value maximisation’ in connection with these areas of linkages. In another test, respondents classified based on various manufacturing sectors have no difference in these areas of linkages between lean and sustainability.

The sample of industries selected for the survey includes ten diverse manufacturing sectors of MSMEs. As the respondents from diverse sectors are included in the sample, the conclusions drawn from this study can take a broad view to a great extent of MSMEs. The affinity of lean, and sustainability, and benefits discovered in this research can provide the support for managers to prevail over the confrontation to either approach at multiple levels. Apart from these, the practitioners can highlight the relevance of lean practices, which would be a requirement for the success of manufacturing MSMEs and their survival in a global environment.

Thus, this chapter statistically identified the various LMPs, sustainability performance measures and areas of linkages between lean and sustainability, which are relevant to MSMEs. The chapter also gives statistical differences among the groups of the MSMEs classified based on the various operational management system variables so that the objectives from one to three stated in section 1.3 are satisfied.

CHAPTER 5

FACTOR ANALYSIS

5.1 INTRODUCTION

The descriptive statistics presented in chapter four shows that MSMEs are convincingly following the LMPs in their operations and benefited to sustainable performance. This chapter presents the results of the factor analysis on the variables used for measuring lean practices and sustainability performance.

Since lean practices are inter-reliant, analysing on single entity practices can be deceptive (Kim et al., 2012; Shah and Ward, 2003). The effect of the lean practices was studied by the various researchers based on the classification and examination as the sets of internally consistent groups of practices. There are various research works available in the literature which studied the impact of lean bundles rather than individual practices comprising each bundle (Agarwal et al., 2013; Bonavia and Marin-Garcia, 2011; Rahman et al., 2010; Shah and Ward, 2003). Although previous research works have conducted factor analysis and assigned bundles/variables to latent constructs of LMPs and sustainability performance, there have been non-uniformity in the definition of bundles and their inclusion in constructs.

In Indian context, attempts to define items and constructs of LMPs particularly in MSMEs have not been developed yet. Hence a factor analysis is to be conducted to identify the latent constructs and their composition of items in MSMEs. In this study, an Exploratory Factor Analysis (EFA) has been used to factorise the variables. Content/face validity, uni-dimensionality and reliability were assessed through factor analysis

The process of identification of underlying structures among the 19 indicator variables of LMPs and 12 indicator variables on sustainability performance, are presented in this chapter. The findings from these factor analyses will define the second order constructs of LMPs and sustainability performance for further analysis proposed using the ‘Structural Equation Modelling (SEM).

5.2 FACTOR ANALYSIS

Factor analysis is an interdependence technique, whose primary aim is to define the underlying structure among the variables in the analysis. This method analyses the interrelationship among a large number of variables and to group them accordingly to their common core dimensions as factors with minimal loss of information (Hair et al., 2013). Factors are formed by describing the variability among the observed and correlated variables into a potentially low number of unobserved variables. This method explores such joint variations in response to unobserved latent variables.

The observed variables are modelled as a linear combination of potential factors, plus error terms. By providing an empirical estimate of the structure of the variables considered, factor analysis becomes an objective basis for creating summated scale. The factor analysis is classified into two types as Exploratory Factor Analysis (EFA) and Confirmatory Factor Analysis (CFA) (Byrne, 2010; Williams et al., 2010).

5.2.1 EXPLORATORY FACTOR ANALYSIS

EFA is an analysis of exploratory type and is used to identify the complex interrelationships among the variables, and group these variables as part of unified concepts. This method helps the researcher to draw the main dimensions of the area of interest to derive a theory or a model from the reasonably large set of variables. The groups formed from interrelated variables are called factors (Hair et al., 2013).

The distinctive feature of EFA is that the factors are derived from statistical results, not from theory (Hair et al., 2013). The EFA is performed without any prior idea of, which factors indeed subsist and which variables loads to each group formed. The researchers use the conventional procedure and rules to arrange and load the variables on factors and to fix the number of factors. The EFA explores the data and provides the researcher, the information about how many factors are needed to best represent it. The correlation between the variables and factors known as factor loading gives the nature of a particular factor.

5.2.2 CONFIRMATORY FACTOR ANALYSIS

This approach tests the hypotheses that the items are associated with specific factors. CFA uses Structural Equation Modeling (SEM) to test a measurement model whereby loading on the factors allows for evaluation of relationships between observed variables and unobserved variables. CFA is similar to EFA in some respect, but philosophically different.

In conducting CFA, the details such as the number of factors and the factors on which each variable load is to be specified for a given set of variables. Hypothesised models are tested against actual data, and the analysis would demonstrate loadings of observed variables on the factors, as well as the correlation between the latent variables. CFA is applied to test the extent to which researcher's a-priory, the theoretical pattern of the factor loading of pre-specified constructs representing the actual data.

5.3 STEPS IN EFA

An EFA consist of a series of procedures and steps to be followed in building clear decision pathways. First, it is required to define the objectives of the factor analysis concerned with the research problem. Figure 5.1, shows the systematic steps followed in EFA by the most of the researchers (Williams et al., 2010; Ogunbiyi, 2014).

1 Data Suitability Tests for Factor Analysis

Suitability of the data depends on the assumptions underlying factor analysis, which is more conceptual than statistical (Hair et al., 2013). In factor analysis, sample size, factorability of the correlation matrix, Kaiser-Meyer- Olkin (KMO) measure of sampling adequacy, and Bartlett’s test of sphericity are the criterion to check the suitability of data for analysis. The requirement of minimum sample size is to be satisfied for conducting factor analysis.

The literature shows different opinions about the sample size. The minimum absolute sample size is 50 in general, and the recommended minimum number of observations is 100 or larger for conducting the factor analysis (Hair. et al., 2013, Sapnas and Zeller, 2002). In another aspect, the recommended minimum ratio of the number of observations to some variables to be analysed is 5:1 and the more appreciable sample size is up to 10:1. Similarly, for considering the data's suitability, correlations in the data matrix is also an important criterion to be considered. Sufficient correlations shall exist among the variables to consider in factor analysis. The thumb rules suggest that the values of correlation coefficients in correlation matrix above ±0. 30 can be considered as minimum, ±0. 40 is important, and ±0. 50 are practically significant for conducting factor analysis (Tabachnick and Fidell, 2007; Hair et al., 2013)

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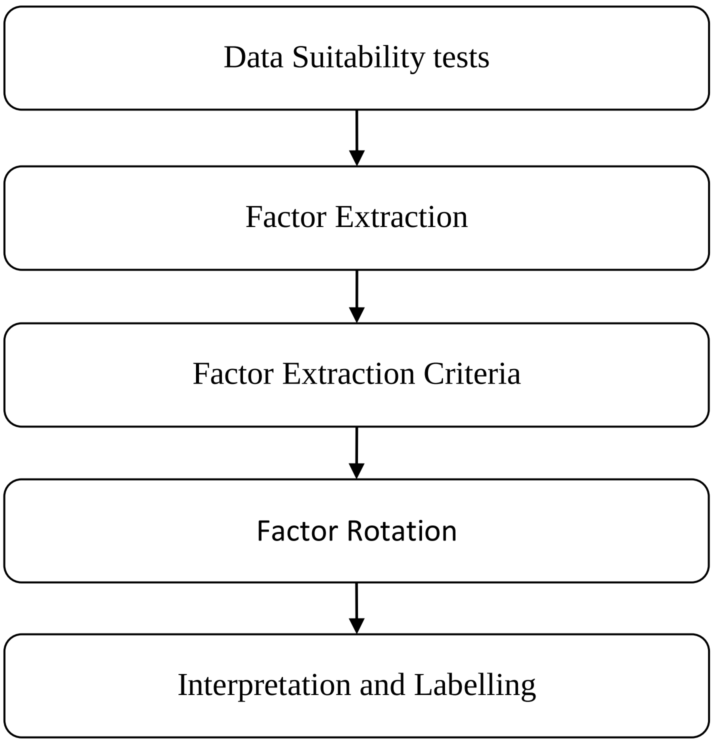

Figure 5.1 Steps in Factor Analysis

‘Kaiser-Meyer-Olkin (KMO) Measure of Sampling Adequacy’ and ‘Bartlett's Test of Sphericity’ are the two commonly adopted tests. If the ‘KMO measure of sample adequacy’ value is between 0.5 and 1.0 is the representation of the usefulness of factor analysis with the particular data. (Urban and Naidoo, 2012; Kaiser, 1974).

The ‘Bartlett’s Test of sphericity’ tests whether the correlation matrix is an identity matrix indicating the non-existence of correlation among the variables.

If the significance value is 0.05, this suggests that the factor analysis approach about the relevant data may be useful. (Hair et al., 2013).

2 Factor Extraction

This is the process of extracting the best linear combinations of variables explaining variance in the data than any other linear combination (Hair et al., 2013). The ‘Principal component analysis’ (PCA), ‘Principal axis factoring’ (PAF) are the common methods employed for factor extraction (Pett et al., 2003; Thompson, 2004).

Various criteria are used to assist the factor extraction. The ‘Kaiser‘s criteria’ based on ‘Eigenvalues’ (Kaiser, 1974), the ‘Scree test’ (Cattell, 1966), and the ‘cumulative percentage of variance extracted’ are the commonly used criteria for factor extraction. Factors are extracted with the rules of Eigenvalues either greater than one or by fixing the number factors to be a fixed one, based on prior expectations. The Scree plots are the graphical representation of Scree tests by drawing a straight line through the smaller Eigenvalues, at which the above conditions are fixed. The total variance explained in social science, and management researchers are acceptable for a minimum value from 50-60 percentages (Pett et al. 2003, Hair et al. 1995).

3 Factor Rotation

The rotation of factors used to get more interpretable and simplified solutions from the factor extraction results. The ‘Orthogonal rotation’ and ‘oblique rotation’ are the two commonly used techniques for factor rotation. There are several options for both rotation techniques. The orthogonal rotation could be Varimax or Quartimax, while oblique rotation could be Olbimin or Promax. The Orthogonal Varimax rotation was first developed by Thompson (2004), and it is the most common rotational technique used in factor analysis, which is capable of producing factor structures that are not correlated (Costello and Osborne, 2005). In contrast, Oblique rotation produces factors that are correlated. This is often seen as more accurate for research involving human behaviours, or when data do not meet prior assumptions (Costello and Osborne, 2005).

4 Interpretation and Labelling

In the interpretation stage, the factors are generated, and attributed variables are examined to identify the common property to name the variables (Williams et al., 2010). In general, at least two variables must load on the factor, so it can be given a meaningful interpretation (Henson and Roberts, 2006). The labelling of factors is a subjective, logical, and inductive process (Pett et al. 2003). The meaningfulness of latent factors is ultimately dependent on the logical definition raised by the researcher (Henson and Roberts, 2006).

5.4 EFA OF LEAN MANUFACTURING PRACTICES

The EFA was conducted using the principal component method with the condition of Eigenvalues greater than 1.0. Normality, linearity, homoscedasticity and homogeneity of the sample are assumed for performing the factor analysis as alike to similar researches (Mitra and Datta 2014). Sample adequacy for LMPs was tested by the KMO measure of sample adequacy and Bartelett's test for sphericity. Details of the KMO test and Bartlett's tests are shown in Table.5.1. KMO measure of sampling adequacy test for lean manufacturing practices gives a KMO value of 0.877, which go above the suggested threshold value of 0.6. Bartelett's test for sphericity gives a chi-square value of 1723.568 with a degree of freedom (d.f) of 171. A significant p values ($p < 0.05$) reject the null hypothesis of 'correlation matrix is an identity matrix' indicates the suitability of the data for factor analysis.

Table 5.1 K-M-O and Bartlett's Test Results of LMPs

Kaiser-Meyer-Olkin (KMO) Measure of Sampling Adequacy		0.877
Bartlett's Test of Sphericity	Approx. Chi-Square	1723.108
	df	171.0
	Sig.	0.000

The communality plays a significant role in factor analysis procedure. Communality is defined as the total amount of variance a variable has in common with the constructs upon which it loads (Byrne, 2010. The minimum threshold value for the communality is accepted at 0.5 (Hair et al., 2013). In common practice, if a variable loaded on a factor with a value less than 0.4 or significantly loaded on more than one factor, that variable is deleted from the further analysis (Hair et al, 2013).

Indicators with low communality values (< 0.5) are deleted and recalculated for new communalities. In the first iteration, factor analysis gives a cumulative variance explained as 56.96 percent with 4 factors. The Table. 5.2 gives the initial and extracted communalities obtained from the initial analysis with 19 variables. On further analysis, the variables loaded greater than 0.40 on more than one constructs or loaded into a factor that did not match with the theory or logic were avoided

Table 5.2 Initial Communality Values of LMPs

Lean Manufacturing Practices variables	**Initial**	**Extraction**
LMP01	1.000	0.667
LMP02	1.000	0.743
LMP03	1.000	0.521
LMP04	1.000	0.684
LMP05	1.000	0.571
LMP06	1.000	0.588
LMP07	1.000	**0.277**
LMP08	1.000	0.576
LMP09	1.000	0.636
LMP10	1.000	0.589
LMP11	1.000	0.606
LMP12	1.000	0.601
LMP13	1.000	0.532
LMP14	1.000	0.558
LMP15	1.000	0.671
LMP16	1.000	0.646
LMP17	1.000	**0.406**
LMP18	1.000	0.562
LMP19	1.000	0.588

Variables with low communality LMP07 (0.277) and LMP17 (0.406) are deleted from the variable list and was conducted factor analysis again. The initial and extraction communalities values from this test are shown in the Table 5.3. From Table 5.3, it is observed that all the communalities values are above the threshold value equal to 0.5.

Table 5.3 Communality Values after Dropping the Low Communality Values of LMPs

Lean Manufacturing Practices	Initial	Extraction
LMP01	1.000	0.687
LMP02	1.000	0.751
LMP03	1.000	0.544
LMP04	1.000	0.694
LMP05	1.000	0.598
LMP06	1.000	0.587
LMP08	1.000	0.589
LMP09	1.000	0.667
LMP10	1.000	0.630
LMP11	1.000	0.611
LMP12	1.000	0.602
LMP13	1.000	0.536
LMP14	1.000	0.582
LMP15	1.000	0.688
LMP16	1.000	0.636
LMP18	1.000	0.562
LMP19	1.000	0.586

As the communalities values are above 0.5, varimax rotation is conducted with a condition ‘Eigen value greater than one’. The initial rotated component matrix obtained from the analysis is shown in Table 5.4. This results show that four factors are extracted. However, the variable LMP13 is not showing a significant loading and the variable LMP19 is cross loaded with two factors. Hence, these variables may be eliminated, but according Hair et al. (2013), this is a problem situation for researcher in which variables with sufficient communality values show cross loading or absence of significant loading. As a remedy, Hair et al. (2013) have also suggested that, without eliminating these variables the factor model may be respecified by changing the condition of extraction, to get a factor structure with empirical and conceptual support.

Table 5.4 Initial Rotated Component Matrix of LMPs

Lean Manufacturing Practices	**Component**			
	1	**2**	**3**	**4**
LMP03		0.598		
LMP14		0.641		
LMP16		0.778		
LMP15		0.827		
LMP01				0.798
LMP02				0.827
LMP06				0.693
LMP13				
LMP19		**0.412**	**0.524**	
LMP18		0.521		
LMP09			0.772	
LMP08			0.761	
LMP10			0.772	
LMP12	0.756			
LMP05	0.729			
LMP11	0.745			
LMP04	0.799			

Hence, in the next stage, without deleting the variables LMP13 and LMP19, the factor analysis was again conducted by changing the condition of 'Eigen value greater than one' to a condition specifying a fixed number of factors. Thus, an analysis was conducted, by fixing the number of factors to be extracted to the next higher value equal to '5' than the previous number of factors extracted.

The new rotating component matrix obtained is shown in Table 5.5. This result suggests five factors to represent all the lean manufacturing practices. During this iteration, the cross loading of the variable were eliminated. The Scree plot obtained from the output results is shown in Figure 5.2. In this diagram, the Eigenvalue of fifth factor is very close to unity (0.980) and thus confirms the choice of the five factors in the solution.

Table 5.5 Final Rotated Component Matrix of LMPs

Lean Manufacturing Practices	**Components**				
	1	**2**	**3**	**4**	**5**
LMP03		0.582			
LMP14		0.568			
LMP16		0.779			
LMP15		0.861			
LMP01			0.805		
LMP02			0.821		
LMP06			0.686		
LMP13					0.831
LMP19					0.574
LMP18					0.707
LMP09				0.801	
LMP08				0.749	
LMP10				0.785	
LMP12	0.723				
LMP05	0.741				
LMP11	0.744				
LMP04	0.817				

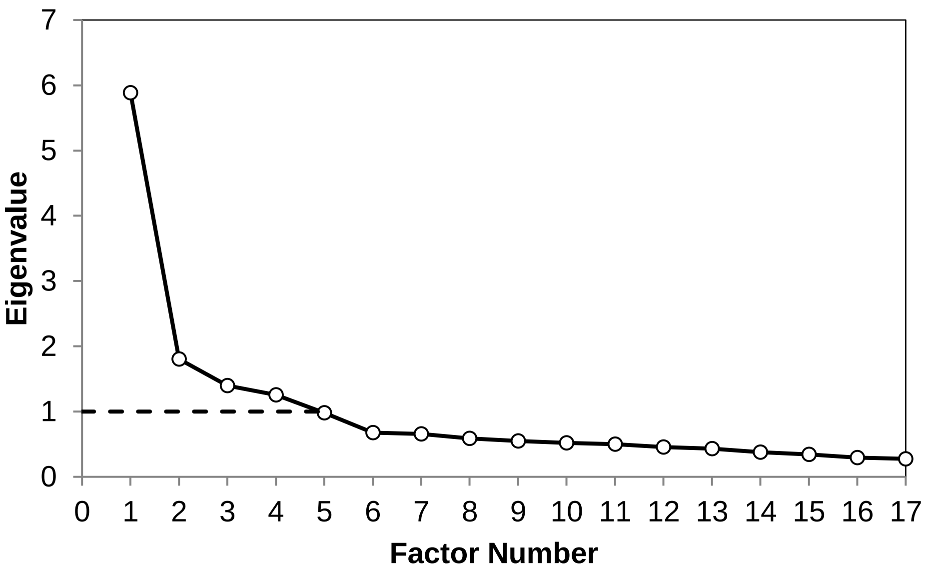

Figure 5.2 Scree Plot of Factor Rotation of LMPs.

The total variance explained by these generated factors is shown in Table 5.6. From this table, the five factors selected have a rotation sum of squared loadings equal to 66.48 percentages, which indicates the percentage of the total variance explained by these five factors. This range of percentage as total variance explained is acceptable as per the previous researchers in this type (Hair et al., 2013; Rahman et al., 2010).

Table 5.6 Total Variance Explained by the Factors of LMPs

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
	Total	Variance %	Cumulative %	Total	Variance %	Cumulative %	Total	Variance %	Cumulative %
1	5.886	34.624	34.624	5.886	34.624	34.624	2.750	16.175	16.175
2	1.807	10.630	45.254	1.807	10.630	45.254	2.351	13.827	30.002
3	1.400	8.235	53.488	1.400	8.235	53.488	2.173	12.784	42.786
4	1.257	7.395	60.884	1.257	7.395	60.884	2.124	12.493	55.278
5	0.980	5.764	**66.648**	0.980	5.764	66.648	1.933	11.369	66.648
6	0.675	3.970	70.618						
7	0.658	3.869	74.486						
8	0.588	3.458	77.944						
9	0.548	3.221	81.166						
10	0.521	3.066	84.231						
11	0.502	2.953	87.185						
12	0.456	2.680	89.864						
13	0.432	2.543	92.407						
14	0.379	2.229	94.636						
15	0.343	2.018	96.654						
16	0.293	1.724	98.378						
17	0.276	1.622	100.000						

5.5 EFA OF LMPS - RESULTS

The EFA of LMPs generated five factors. The name and definitions of these factors are given in Table 5.7. The first factor includes four variables (LMP12, LMP05, LMP11, and LMP04). These variables are the lean practices related to employees and workforce, and hence this factor is named as Workforce management practices (W). This factor contributes the highest portion of variation in the total variance explained by all the five factors. The second factor formed by variables (LMP03, LMP14, LMP16, and LMP15) is related to flow management and hence this factor is termed as Flow management practices (F). Similarly, the third factor with three variables (LMP01, LMP02, and LMP06) which are related to manufacturing processes and hence known as Process management practices (P).

Table 5.7 Lean manufacturing practice Constructs-Definitions

Sl.No.	Constructs	Definition	Supporting literature
1	Workforce Management Practices (W)	Practices for the involvement of workers in continuous quality improvement programs, expansion of their autonomy and responsibility. Concentrated on the reduction of wastes due to underutilized people, waiting, and unnecessary Motion	Shah and Ward (2003, 2007); Al-tahat and Jalham (2015)
2	Flow management practices (F)	A set of interrelated practices for managing production flow concentrated on the reduction of waste due to excess inventory, over production and unnecessary delays on flow time.	Shah and Ward (2003), Swink et al. (2005)
3	Process Management Practices (P)	Practices to sustain the quality standards of processes. Mainly concentrated on waste reduction due to unnecessary motion, over processing and waiting.	Panizzolo et al. (2012)
4	Supplier Management Practices (S)	Practices that focus on managing the relationships between the manufacturing firm and its suppliers. Concentrated on the reduction of waste due to inventory and waiting.	Shah and Ward (2003, 2007); Al-tahat and Jalham (2015); Panizzolo et al.(2012)
5	Customer Focus Practices (C)	Practices that are directly related to customers, for establishing links between customer satisfaction and their needs. Mainly concentrated on the reduction of wastes due to defect, transportation and waiting.	Al-tahat and Jalham (2015); Panizzolo et al.(2012)

The fourth factor with three variables (LMP09, LMP08, and LMP10) are the practices related to suppliers and hence termed as Supplier management practices (S). The fifth factor includes three variables (LMP13, LMP19, and LMP18) which are related to customer management and hence termed as Customer management practices (C). In short, the construct LMPs in MSMEs can be represented as five factors, namely, ‘Workforce management practices’, ‘Flow management practices’, ‘Process management practices’, ‘Supplier management practices’, and ‘Customer management practices’. These findings are in line with the similar researchers (Khanchanapong et al., 2014). These five factors listed in Table 5.7 will represent all variables of LMPs in the further analysis of this research.

5.6 EFA OF SUSTAINABILITY PERFORMANCE

As similar to the EFA of LMPs, the EFA of Sustainability performances are conducted using the principal component method with the condition of Eigenvalues greater than 1.0. Normality, linearity, homoscedasticity and homogeneity of the sample are assumed for conducting the factor analysis (Mitra and Datta 2014).

Details of the ‘KMO test’ and ‘Bartlett’s tests’ are shown in Table 5.8. ‘KMO measure of sampling adequacy’ test for sustainability performance indicators give a KMO value of 0.871, which go above the suggested threshold value of 0.6. ‘Bartelett’s test for sphericity’ gives a chi-square value of 1129.78 with a degree of freedom (d.f) of 66. A significant p values ($p < 0.05$) reject the null hypothesis the ‘correlation matrix is an identity matrix’ and indicates the suitability of the data for factor analysis.

Table 5.8 K-M-O and Bartlett’s Test Results of Sustainability Performance.

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		0.871
Bartlett's Test of Sphericity	Approx. Chi-Square	1129.778
	d.f	66
	Sig.	0.000

The rotated component matrix using the principal component method with the condition of ‘Eigen values greater than 1.0’, suggests three constructs in the first iteration to represent all the 12 sustainability performances. These three factors explain

62.36 percentage of total variance in the first iteration. Table.5.9 gives the initial and extracted communalities obtained from the initial analysis with 12 variables.

Table 5.9 Initial Communality Values of Sustainability Performance

Sustainability performance Variables	**Initial**	**Extraction**
SP01	1.000	0.565
SP02	1.000	0.648
SP03	1.000	0.712
SP04	1.000	0.588
SP05	1.000	0.707
SP06	1.000	0.624
SP07	1.000	0.708
SP08	1.000	0.733
SP09	1.000	0.561
SP10	1.000	0.571
SP11	1.000	0.637
SP12	1.000	0.429

Indicator SP12 (Technology improvement) with low communality value equal to 0.408 (< 0.5) is deleted and recalculated for new communalities. The communalities values in the second iteration are shown in the Table. 5.10.

Table 5.10 Communality Values After Dropping the Low Communality Values of Sustainability Performances

Sustainability performance Variables	**Initial**	**Extraction**
SP01	1.000	0.601
SP02	1.000	0.661
SP03	1.000	0.722
SP04	1.000	0.585
SP05	1.000	0.699
SP06	1.000	0.630
SP07	1.000	0.709
SP08	1.000	0.734
SP09	1.000	0.577
SP10	1.000	0.565
SP11	1.000	0.644

As the communalities values are above 0.5 with all variables, the factor rotation was conducted using varimax rotation. The rotated component matrix is shown in Table 5.11. Three factors are extracted, and the corresponding Scree plot is shown in Figure 5.3. The Scree plot confirms the choice of three factors in the solution with respect to the criteria of 'Eigen value greater than one'.

Table 5.11 Final Rotated Matrix for Sustainability Performances

Sustainability performance Variables	**Component**		
	1	**2**	**3**
SP01			0.721
SP02			0.782
SP03			0.819
SP04		0.552	
SP05		0.775	
SP06		0.761	
SP07		0.790	
SP08	0.814		
SP09	0.724		
SP10	0.711		
SP11	0.744		

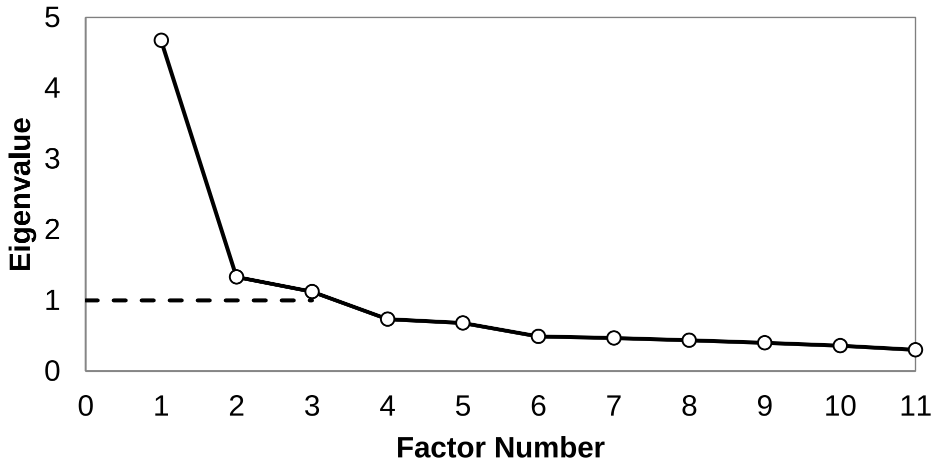

Figure 5.3 Scree Plot of Factor Rotation for Sustainability Performance Variable

The total variance explained by these generated factors is shown in Table 5.12. From this table, the three factors selected have a rotation sum of squared loadings equal to 64.799 percentages, which indicates 64.80 percentage of the total variance is explained by these three factors. This range of percentage as total variance explained is acceptable as per the researches in this type (Hair et al., 2013; Rahman et al., 2010).

Table 5.12 Total Variance Explained by Factors of Sustainability Performance

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
	Total	**Variance %**	**Cumulative %**	**Total**	**Variance %**	**Cumulative %**	**Total**	**Variance %**	**Cumulative %**
1	4.674	42.488	42.488	4.674	42.488	42.488	2.545	23.132	23.132
2	1.330	12.087	54.575	1.330	12.087	54.575	2.375	21.591	44.723
3	1.125	10.225	64.799	1.125	10.225	64.799	2.208	20.077	64.799
4	0.733	6.666	71.465						
5	0.680	6.183	77.648						
6	0.492	4.469	82.118						
7	0.468	4.258	86.375						
8	0.436	3.960	90.336						
9	0.400	3.640	93.976						
10	0.361	3.284	97.260						
11	0.301	2.740	100.000						

5.7 EFA OF SUSTAINABILITY PERFORMANCE - RESULTS

Three factors are generated in the EFA of sustainability performances. The four variables (SP8, SP9, SP10 and SP11) included in the first factor are employee safety and health, labour relationship, training and customer satisfaction. These performances have a common feature of social value, and hence this factor is named as social sustainability performances. From Table 5.12, this factor contributes to the highest portion of variation among the total variance explained by all the factors. The four variables (SP04, SP05, SP06 and SP07) in the second factor are the reduction in environmental business wastage, reduction in emission/ unit of production, and reduction in material usage/ unit of production and reduction in energy were the performances in environmental aspects. This factor was named as Environmental sustainability performance. The three variables in third factor, are SP01, SP02 and SP03 representing a reduction in operational cost, growth in profit and market performance are related to economic performances. So, the third factor is named as economic sustainability performance.

Hence, the sustainability performances of MSMEs are grouped into three constructs such as social sustainability performances, environmental sustainability performances and economic sustainability performances. The definitions of constructs in terms that can incorporate from the sustainability principles and previously related literature are shown in Table 5.13.

Table 5.13 Sustainability Performances Constructs - Definitions

Constructs	Definition	Supporting literature
Social Sustainability Performance	Focuses on useful and fair practices to the workers, customers, local community and region in which firm do business	Wang et al., 2015; Shah and Ward, 2007; Lozano and Huishingh, 2011
Environmental Sustainability Performance	Focuses on any harm caused to the environment by addressing the use of materials, energy management and reduction of pollution and waste.	Wang et al.,2015; Azevedo et al.,2012; Martínez-Jurado and Moyano-Fuentes, 2014;
Economic sustainability performances	Focuses on short-and long-range profitability and economic viability	Wang et al., 2015; Martínez-Jurado and Moyano-Fuentes, 2014

5.8 VALIDITY AND THE RELIABILITY OF EFA

Table 5.14 gives the list of constructs with corresponding variables as given in the questionnaire. Variable codes were modified for further analysis, based on their corresponding constructs in which it was loaded, is also given in the table 5.14 against their question codes.Internal consistency reliability of all constructs can be assessed by calculating the value of Cronbach’s alpha. The Cronbach's alpha values if exceeded 0.7 is typically considered adequate (Cronbach, 1951; Nunnally. 1978) and acceptable if atleast 0.6 (Chen and Paulraj, 2004). The Table 5.14, gives the values of Cronbach's alpha of each construct with corresponding variables of LMPs and sustainability performance. Table 5.14 shows that values of all Cronbach's alphas are between 0.6 and 0.9 and are in the acceptable range, which demonstrates satisfactory internal consistency reliability of all dimensions.

Table 5.14 List of Constructs and Indicators with Question Code and New Variable Code with Cronbach's Alpha

Construct	Question Code	Variable Code	Variable	Cronbach's Alpha
Workforce Management Practices **(W)**	LMP12	W1	During problem-solving sessions, we make an effort to get all team members' opinions and ideas before making a decision	0.804
	LMP05	W2	Many equipment problems have been solving through small group sessions	
	LMP11	W3	We form teams capable to do their daily work without formal leadership.	
	LMP04	W4	Workers carry out routine maintenance on all equipments (eg: Cleaning, lubrication or small repairs) following standard procedures	
Flow Management Practices **(F)**	LMP03	F1	We focus to reduce process set up time—the time required to prepare or refit equipment, workstations etc.	0.773
	LMP14	F2	We usually complete our daily schedule as planned	
	LMP16	F3	The layout of the shop floor facilitates low inventories and fast throughput	
	LMP15	F4	We have a small amount of work-in-process inventory	
Process Management Practices **(P)**	LMP01	P1	Our plant emphasise putting all tools and fixtures in their proper place	0.752
	LMP02	P2	We use standardized and documented processes which are well instructed to our employees	
	LMP06	P3	Our plant following either preventive/predictive maintenance	
Supplier Management Practices **(S)**	LMP09	S1	We have built close, long-term relationships with our suppliers	0.731
	LMP08	S2	We can depend on time delivery of our suppliers	
	LMP10	S3	We have high levels of information transparency or information sharing with our suppliers	
Customer Management Practices **(C)**	LMP13	C1	We systematically and regularly measure customer satisfaction	0.769
	LMP19	C2	Customer needs and expectations are effectively disseminated and understood throughout the workforce	
	LMP18	C3	We have an effective process for resolving customers' complaints	

Construct	Question Code	Variable Code	Variable	Cronbach's Alpha
Economic Sustainability Performance **(ECP)**	SP01	ECP1	Low Operational cost	0.752
	SP02	ECP2	Growth in Market Value	
	SP03	ECP3	Growth in Profit	
Environmental Sustainability Performance **(ENP)**	SP04	ENP1	Reduction in Environmental Business wastage (ie Non Value added activities)	0.802
	SP05	ENP2	Reduction in Emission /unit of Production	
	SP06	ENP3	Reduction in Material Usage/ Output	
	SP07	ENP4	Reduction in Energy/ Fuel usage	
Social Sustainability Performance **(SOP)**	SP08	SOP1	Safety and Health	0.787
	SP09	SOP2	Labour relationship	
	SP10	SOP3	Training and Education	
	SP11	SOP4	Decrease in Rate of consumer complaints	

5.9 CONCLUSION

This chapter focussed on the exploratory factor analysis of the variables of Lean manufacturing practices and sustainability performance. In both cases, the KMO test and Bartlett's test for sphericity are conducted on the data to test the suitability of data to conduct factor analysis. The results of factor analysis show that LMPs can be grouped into five significant and meaningful constructs in MSMEs. These five constructs of Lean manufacturing practices are categorized as 'workforce management practices', 'flow management practices', 'process management practices', 'supplier management practices' and 'customer management practices'. These five factors explaining 66.65 percentage of the total variance explained. These findings are comparable with similar studies conducted earlier.

Similarly, factor analysis conducted shows that sustainability performances in MSMEs can be grouped into three meaningful and significant constructs. These three constructs of sustainability performances are categorised as 'economic sustainability performance', 'environmental sustainability performance', and 'social sustainability performance'. These three factors explaining 64.78 percentage of the total variance explained. These results are in line with the 3BL concept of sustainability.

CHAPTER 6

STRUCTURAL EQUATION MODELING

6.1 INTRODUCTION

The factors of LMPs and Sustainability performance identified by conducting Exploratory Factor Analysis (EFA) of variables and survey results were explained in chapter 5. Five constructs were derived to represent LMPs and three constructs to represent the sustainability performance. These constructs are used in SEM to analyse the effect of five LMP constructs on the three sustainability performance constructs. The formulation of SEM models, hypotheses development and the results of SEM analysis are described in this chapter.

The influence on operational and financial outcomes, generating from the lean implementations on various sectors of manufacturing firms were reported by several researchers (Filho et al., 2016; Bonavia and Marin, 2006; Upadhye et al., 2013; Rahman et al., 2010; Panizzolo et al., 2012; Khanchanapong et al., 2014; Zhou, 2012). The recent researches are conducted on sustainable growth of manufacturing MSMEs (Ciasullo and Troisi, 2013; Cherrafi, et al., 2016). Government authorities are giving more emphasis on developing policies for the sustainable growth as well.

The contributions of lean practices on various dimensions of sustainability performance grouped into economic, social and environmental performances, especially in manufacturing MSMEs are least reported in literature. The researchers have brought out that the adoption of lean principles in various operations of the firms in general is one of the efficient ways towards sustainability (Piercy and Rich, 2015). However, there is no much information available about the interrelationship of sustainability performances grouped into economical, environmental, and social performances.

With the inspiration from literature, three hypotheses of LMPs effects on sustainability performances and three hypotheses of interrelationships of sustainability performances were formulated. Measurement models and structural models were developed and analysed using SEM technique to test the proposed hypotheses. Measurement model and fit indices were checked to test how well the measured variables represent the constructs. Then structural model results were evaluated and summarised to derive the conclusions.

6.2 HYPOTHESIS DEVELOPMENT

Figure 6.1 shows the research framework that expresses the relationship of the LMPs towards the sustainability performance. In this framework, LMP is a construct generated from the supporting five constructs. LMP leads to the environmental sustainability performance, economic sustainability performance, and social sustainability performance. The interrelationship of three-sustainability performance also expressed in this framework. Detailed hypotheses are formulated based on the support of extant literature.

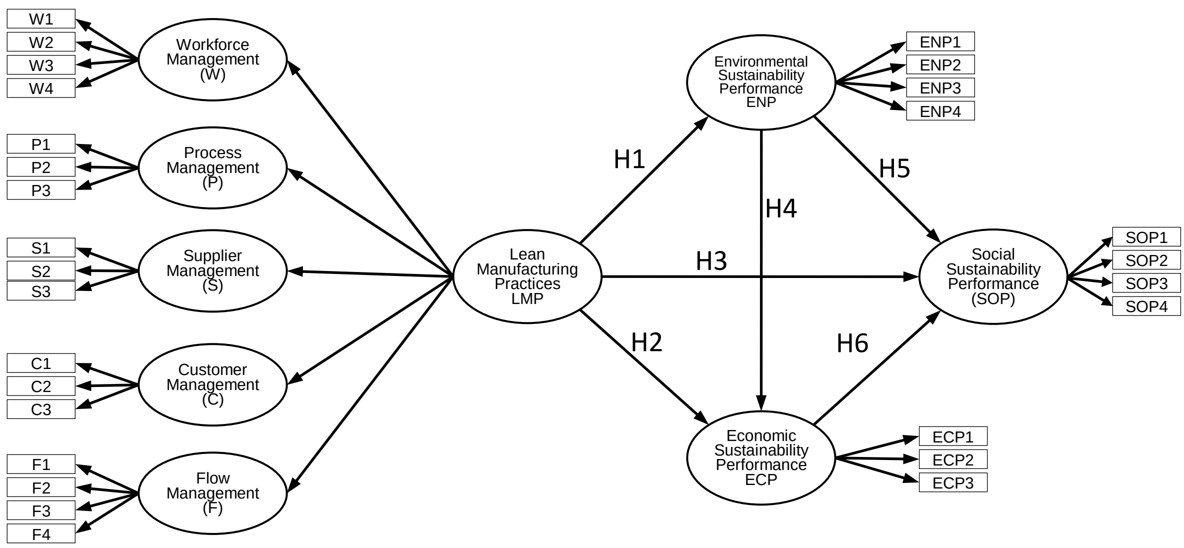

Figure 6.1 Research Framework

6.2.1 RELATIONSHIP BETWEEN LMPs AND SUSTAINABILITY PERFORMANCE

Researchers in different countries have studied the LMPs and its effect on sustainability performance. Three hypotheses were prepared that link between LMPs with environmental, economic and social performances. The development of the hypotheses, its literature support and the probable reasons for linkage are explained here.

The concept of lean management and environmental sustainability are complementary and governed by three principles, namely the ‘process centred focus,’ ‘waste reduction,’ and ‘high level of people involvement and participation’ (Martínez-Jurado and Moyano-Fuentes, 2014). LMP’s target of zero wastage or zero defect leads to the prevention and reduction of environmental harm. This target is achieved by the efficient use of resources from reduced waste, reduced quantity of material lost to scrap and less energy or time consumed in producing the required output (Chugani et al., 2017; King and Lenox 2001; Ball, 2015). Lean is an effective method for the conservation of resources, combating global warming and saving energy (Chugani et al., 2017). Just in time (JIT) strategy has a positive linkage with waste reduction, pollution prevention, and the reduction of emission of Volatile Organic Compounds (VOC) (Rothenberg et al., 2001). The concurrent lean and green practices have a synergistic effect on environmental performances by reduction of gas emissions in transport and logistics operations of the firms (Garza-Reyes et al., 2016).

Information sharing by the impact of lean practices reduces ‘bullwhip effect' thereby plummeting overproduction and transportation, results in a decrease of waste and pollution (Kainuma and Tawara 2006). Similarly, lean practices such as 5S and Kaizen encourage a neat and organised work environment, which motivates employees to properly discard of the production rejects (Vinodh et al., 2011). Kaizen helps to trim down material wastes and pollution, which ensures a safe and healthy place to work (Fliedner, 2008; Pampanelli et al., 2014; Vinodh et al., 2010). Pull production practice focus on reducing inventory levels and provides the right materials at the right time to support operational needs. This concept could help increase environmental performances by reducing potential waste from damaged, spoiled, or deteriorated products, avoid excess consumption and waste (Fliedner, 2008; Ng et al., 2015; Rothenberg et al., 2001; Vinodh et al., 2010).

The increased level of people involvement and participation inherent in LMPs such as employee participation in work standardisation, teamwork, and continuous improvement can facilitate environmental focus by adopting environmentally friendly practices, tools, and techniques (Rothenberg et al., 2001). Some authors propose that the environmental considerations are the inherent part of lean and some others suggest it as a coincident part. Continuous improvement of operational performances helps to diminish the use of energy and material and bring down transportation (Ball, 2015). As the energy and transportation costs increase, an increasing number of companies have begun thinking and targeting the energy consumption for Kaizen which is also a reduction of environmental waste (EPA 2003; Overturf et al., 2011, Ball, 2015; Pampanelli et al., 2014). This experience with lean manufacturing leads firms to take up environmental management practices. Thus, the hypothesis H1 is proposed.

Hypothesis1: (H1) - ***Lean manufacturing practices in MSMEs are positively associated with environmental sustainability performance***.

Previous empirical researches are showing significant evidence on the influence of LMPs to operational (Filho et al., 2016; Narasimhan et al., 2005; Shah and Ward, 2003; Rahman et al., 2010; Belekoukias et al., 2014) and financial (Hofer et al., 2012; Fullerton and Wempe 2009; Yang et al., 2011; Camacho-Miñano et al., 2013) performances. Improving operational performance such as delivery time, speed, quality, and flexibility lead to cost and waste reduction (Khanchanapong et al., 2014, Bortolotti et al., 2015) which would positively affect financial performances (Hofer et al., 2012). Reducing waste in the form of defect and improving productivity leads to lowering costs and increases return on assets of organisation (Yang et al., 2011). TQM practices in SMEs are indirectly related to financial performances (Herzallah et al., 2014). Organizations can improve their market acceptance, and turnover, with their reputation for quality (Mosey et al., 2003). Most of the LMPs such as JIT, Kaizen and TQM are efficiently instituted for sustainable and cost-effective growth (Yang et al., 2011; Martínez-Jurado and Moyano-Fuentes, 2014). Hence, the second hypothesis H2 is proposed.

Hypothesis 2: (H2) - *Lean manufacturing practices in SMEs are positively associated with economic sustainability Performance.*

The initial focus of lean manufacturing is on the people and then on processes while maintaining an enterprise view as well (Martínez-Jurado and Moyano-Fuentes, 2014). The human element is standing as an essential primary component of any LM sysyem (Mostafa et al., 2013). The leading strategy of lean is the respect for people, followed by continuous process improvement (Longoni et al., 2013). There is a real concord on the LM to incorporate ergonomic standards in the design of workstations to ensure the safety and health in the work milieu (Vinodh et al., 2011; Longoni et al., 2013). Besides the welfare of the workers, lean focuses on the quality and safety of the products (Khanchanapong et al., 2014; Belekoukias et al., 2014). The 5S practice encourages the maintenance of a clean and organised work environment which helps to improve the handling and storage of materials including hazardous materials. This modified workplace reduces the risks of spills and mishandling and provides clean and accident-free work places (Fliedner, 2008; Vinodh et al., 2011; Chiarini, 2014). Vinodh et al. (2011) have justified an evolution from 5S to 7S to admit a broader range of topics relating to health, safety, and sustainability.

Kaizen Provides a problem–solving culture with scientific and structured thinking, which helps organisations to develop the engagement of employees and unleash their creativity for the promotion of innovation for the environmental and social progress (Fliedner, 2008; Pampanelli et al., 2014; Vinodh et al., 2010). Total Productive Maintenance (TPM) promotes preventive and proactive maintenance of equipment to maximise its useful life and avoids processed failures that reduce breakdown and labour rates. This situation increases employee health and safety because new technologies are often substituted for older machines which would result in reducing breakdowns with potential for injury (Chiarini, 2014; Fliedner, 2008; Vinodh et al., 2010).

Lean practices have a positive influence on the attitude of workers (Womack and Jones, 1996) as the employees in lean organisations assume responsibilities that extend beyond their production tasks. Some research reports adverse effects of LMPs such as the stress of the workforce, due to fear of the deprivation of their occupation, low quality of life at work, the repetitiveness of standardised work tasks and loss of autonomy (Hines et al., 2004; Martínez-Jurado and Moyano-Fuentes, 2014). However, teamwork, employee participation, and top management support reduce the stress on employees (Conti et al., 2006). Therefore, the following hypothesis is proposed.

Hypothesis 3: H3 - ***Lean manufacturing practices in MSMEs are positively associated with social sustainability performance.***

6.2.2 RELATIONSHIP BETWEEN ECONOMIC, ENVIRONMENTAL AND SOCIAL SUSTAINABILITY PERFORMANCES

Sustainability performances, namely economic performance, environmental performance and social performance are interlinked. The adoption of environmental management practices by a firm increases the cost burden which changes the cost structures, leading to the reduction of profitability. However, these investments, improve environmental performance regarding the reduction of emission, waste, on-site waste treatment and energy consumption, which are associated with improved financial benefits (King and Lenox, 2001: Jayaraman et al., 2012). Environmental sustainability is a strategic business imperative and must be aligned with the profitability, efficiency, customer satisfaction, quality and responsiveness of organisations (Garza-Reyes, 2015 a, b). The improved environmental performance of a firm enhances its status for the commitment to reduce their ecological change (Starik and Rands, 1995) which in succession positively affects market performance (King and Lenox, 2001).

The market and financial performance of the firm have a positive influence due to the improved business image acquired by the customer satisfaction, customer-firm identification and loyalty derived from the improved environmental performance of the enterprise (Luo and Bhattacharya, 2009). Reduced business waste or non-value-added activities using less material, energy, and resources are environmentally as well as economically beneficial as they reduce operational costs (Azevedo et al., 2012).

Improved economic and environmental sustainable performances have direct and indirect effects on social performances. The increased production rate and workloads cause a more social impact as higher workload results in more mental and physical challenges of workers and may lead to frequent worker injuries. Ineffective waste management and environmental management may lead to many social and public health problems. Reduced air emission, wastage, and energy consumption lead to significant benefits to society regarding the improvements in comfort, health, and better labour relationships. Thus the following three hypotheses (H4, H5, and H6) were proposed.

Hypothesis 4: (H4) - ***Environmental sustainability performance and economic sustainability performance in MSMEs are significantly correlated.***

Hypothesis 5 (H5) - ***Environmental sustainability performance and social sustainability performance in MSMEs are significantly correlated.***

Hypothesis 6: (H6) - ***Economic*** **sustainability** ***performance and social sustainability performance in MSMEs are significantly correlated.***

6.3 CONFIRMATORY FACTOR ANALYSIS

CFA is used to provide a confirmatory test of the measurement theory. Measurement theory specifies how measured variables logically and systematically represent constructs involved in a theoretical model (Hair et al., 2013). Six hypotheses supported by literature review were present in the previous section. Details of questionnaire development, sample selection, respondents details and description of variables are already described in the earlier chapters.

6.3.1 CONSTRUCTS AND VARIABLES

Based on chapter 5, the five constructs selected for LMPs are named and coded as workforce management(W), flow management(F), process management(P), customer management(C), and supplier management(S) practices. The 'workforce management' comprising of four variables (W1 to W4), 'flow management' comprising of four variables (F1 to F4), 'process management' consisting of three variables (P1 to P3), 'customer management' comprising of three variables (C1 to C3) and 'supplier management' comprising of three variables (S1 to S3). Similarly, sustainability performance has three constructs namely economic sustainability performance (ECP) environmental sustainability performance (ENP) and social sustainability performance (SOP). This includes economic sustainability performance' with three variables (ECP1 to ECP3), 'environmental sustainability performance' with four variables (ENP1 to ENP4) and 'social sustainability performance' with four variables (SOP1 to SOP4). The explanations of this variables have given in Table 5.14 of chapter 5.

6.3.2 SAMPLE SIZE ADEQUACY

SEM needs to set a prior sample size based on the latent variables, observed variables and through the power analysis (Westland, 2010; Hair et al., 2013). Sample size criterion was determined traditionally by the use of thumb rules. However, recent researchers are using a priori sample size calculator for SEM (Soper, 2015) based on the power analysis.

1 Thump rule

According to a thumb rule, a simple SEM model can meaningfully test if the sample size is 100 or more (Tuanmat and Smith, 2011). Usually, a sample size of between 100 to 150 is considered the minimum size (Anderson and Gerbing, 1988; Ding et al., 1995). In a different opinion, a sample size of 200 may be required to generate valid fit measures and to avoid drawing incorrect inferences (Smith and Langfield-Smith, 2004). According to '$N \geq 100$' thumb rule, a sample size of less than 100 is often considered small, a sample size between 100 and 200 is medium, and a sample size exceeding 200 is large (Kline, 2005). Since this study has 252 samples, sample size is adequate.

2 Priori sample size calculator for SEM (Soper, 2015)

The sample size criterion should be determined through power analysis for SEM (Hair, et al., 2013). Soper (2015) has proposed a-priori sample size calculator for SEM. It is available as a free page in the internet. The screen shot of the output returned by sample size calculator is shown in Figure 6.2. This calculator requires input data, such as the anticipated effect size, statistical power levels, the number of observed and latent variables in the model, and the desired probability, to detect the minimum sample size for SEM technique (Westland, 2010).

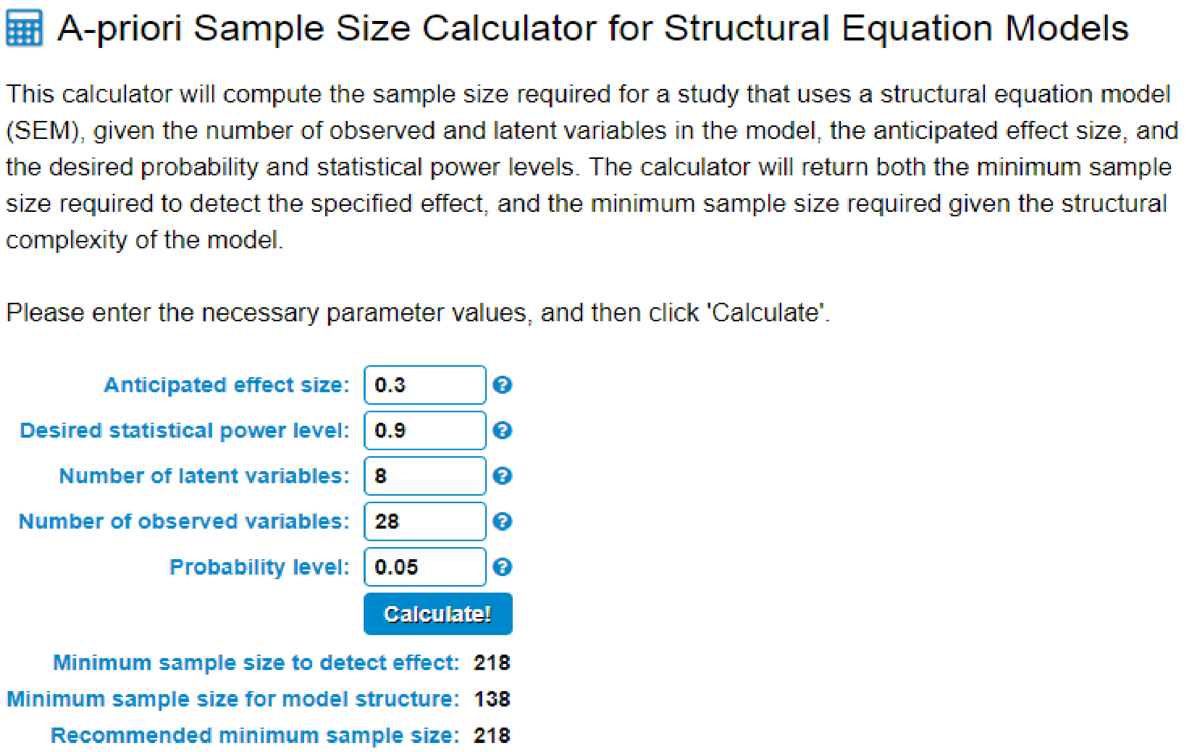

Figure 6. 2 The Screen Shot of the Output of a Priory Sample Size Calculator.

Inputting the required information such as,

Desired statistical power level = 0.90 (should be 0.8 or above)

No observed variables = 28 (17 variable for LMP + 11 variables for sustainability performance)

No of constructs = 8   (5 for LMPs and 3 for Sustainability Performance)

Probability level = 0.05 (95% confidence level)

Anticipated effect size of = 0.3 (0.5-High, 0.3- Medium, 0.1-Low effect size).

The calculator show the minimum sample size to detect the effect as 218 and minimum sample size for model structure as 138. The recommended minimum sample size is the highest value of the minimum sample sizes of both to detect the effect and model structure. Hence, the required number of the sample size from the calculator is 218. Since 252 usable samples are available for this study, the sample size is sufficient for getting the reliable results.

6.4 MEASUREMENT MODEL

SEM is an effective statistical method that seeks to analyse the relationship between multiple variables by the measurement and structural models ((Hair et al., 2013; Vinodh and Joy, 2012). The measurement model defines the relations between the observed variables to unobserved variables (Byrne, 2010). It presents how the measured variables represent the theory (Hair et al., 2013).

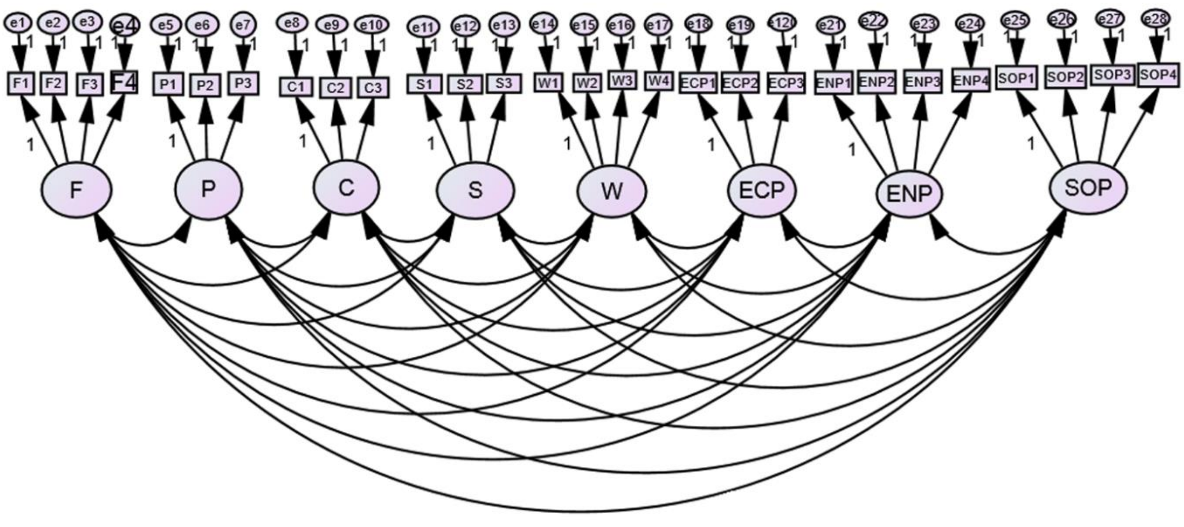

Figure 6.3 Measurement Model

Figure 6.3 shows the measurement model developed for this study The hypothesised relations between variables are calculated through AMOS in SPSS with the maximum likelihood estimate. CFA entail the data which satisfy the normality assumptions essential for SEM (Bortolotti et al., 2015). An iterative alteration procedure, based on CFA, permitted concurrent modification of the measures for the evaluation of the uni-dimensionality of the first- and second-order constructs.

6.5 MEASUREMENT MODEL VALIDITY AND RELIABILITY

The First-order measurement models of the constructs are derived, and overall fit is evaluated. The degree of freedom is calculated as the difference between a number of distinct sample moments and number of distinct parameters to be estimated from the model (Byrne, 2010). The number of distinct sample moments is the sum of unique variance and co-variance terms in the model. According to Hair et al (2013), if there are p measured items, the number of unique variance and covariance can be calculated using the formula$1/2p(p+1)$. In this model, 28 measured items and hence the number of distinct sample moments was calculated as 406. The number of distinct parameters or free parameters to be estimated is the sum of factor loadings, factor covariance terms and error variance terms and computed from the model as equal to 84. Table 6.1 gives the calculation of degree of freedom and equal to 322. As the degree of freedom is greater than zero, the derived model is over-identified. Over identified model, satisfy minimum condition to conduct CFA with enough information to identify the solution to a set of structural equations (Hair et al., 2013, Byrne, 2010).

Table 6.1 Computation of Degrees of Freedom

A number of distinct sample moments	406
Number of distinct parameters to be estimated	84
Degrees of freedom (406-84)	322

6.5.1 INTERNAL CONSISTENCY RELIABILITY

Internal consistency reliability of all constructs can be assessed using Cronbach's alpha. Cronbach's alpha exceeds 0.7 is typically considered adequate (Cronbach, 1951; Nunnally. 1978) and acceptable if at least 0.6 (Chen and Paulraj, 2004). From Table 5.13 of chapter 5, the values of Cronbach's alpha for each construct are already shown. The values are found to be between 0.6 and 0.9 which are in the acceptable range, which demonstrates satisfactory internal consistency reliability of all dimensions. Table 5.13 also provides the codes of each construct and variables used in the further analysis.

6.5.2 CONVERGENT VALIDITY

The variables which represent the indicators of a particular latent variable should converge or share a significant proportion of variance in common is the condition for convergent validity (Fullerton and Wempe, 2009; Hair et al., 2013). Table 6.2 gives the results from CFA with individual constructs and its indicators, standard coefficients and corresponding critical values obtained from the analysis. A high loading on a latent factor by each indicator is the requirement for the higher convergent validity (Anderson and Gerbing, 1988). The researchers are commonly followed standardized estimates for the evaluation of convergent validity, as they are constrained to a range between -1.0 and +0.1 (Hair et al., 2013, Byrne, 2010). The common thumb rule for convergent validity is the standardized loading should be 0.5 or higher, and ideally 0.7 or higher (Hair et al., 2013). From Table 6.2, values of all standardized coefficients are above the minimum threshold value (0.5) and most of the values are near or higher than the ideal value (0.7). ‘Critical ratios’ or ‘t-values’ are calculated by dividing standardized estimate by the standard error calculated. Additionally, these values shown in Table 6.2 also indicate convergent validity, significant at $p < 0.001$ with lowest critical ratio values being 8.00.

6.5.3 DISCRIMINANT VALIDITY

Discriminant validity indicates the degree to which each construct is distinct from one another (Schermelleh-Engel et al, 2003; Anderson and Gerbing, 1988, Hair et al., 2013). Discriminant validity occurs if the square root of the Average Variance Extracted (AVE) by each construct go above the corresponding inter-variable correlation (Fornell and Larcker, 1981).

Table 6.2 Results from CFA Summary Data for Individual Construct Indicators

Construct Indicators	Standardized coefficients	Critical ratio
Workforce Management Practices		
W1	0.666	a
W2	0.707	9.173
W3	0.694	9.056
W4	0.791	9.843
Flow Management Practices		
F1	0.673	a
F2	0.746	9.274
F3	0.661	8.362
F4	0.612	8.000
Process Management Practices		
P1	0.725	a
P2	0.794	10.497
P3	0.661	8.734
Customer Management Practices		
C1	0.605	a
C2	0.772	8.889
C3	0.829	9.530
Supplier Management Practices		
S1	0.810	a
S2	0.603	8.224
S3	0.678	8.720
Economic Sustainability Performances		
ECP1	0.676	a
ECP2	0.709	8.611
ECP3	0.750	9.228
Environmental Sustainability Performance		
ENP1	0.707	a
ENP2	0.713	9.600
ENP3	0.654	8.897
ENP4	0.768	10.094
Social Sustainability Performance		
SOP1	0.808	a
SOP2	0.656	9.751
SOP3	0.686	10.854
SOP4	0.686	10.255

Notes: n = 252; a Parameter that was fixed at 1.0

Measurement models are estimated using maximum likelihood

Table 6.3 First-order Inter-Construct Correlations, Reliability and Discriminant validity (n=252)

	C	*F*	*P*	*S*	*W*	*ENP*	*ECP*	*SOP*	*CR*	*AVE*	*MSV*
C	**0.741**								0.783	0.550	0.333
F	0.450	**0.675**							0.714	0.456	0.287
P	0.573	0.450	**0.731**						0.694	0.534	0.329
S	0.577	0.481	0.399	**0.702**					0.742	0.493	0.345
W	0.559	0.536	0.525	0.324	**0.713**				0.807	0.513	0.312
ENP	0.560	0.472	0.423	0.445	0.322	**0.711**			0.804	0.506	0.436
ECP	0.471	0.458	0.522	0.587	0.297	0.647	**0.712**		0.755	0.507	0.419
SOP	0.515	0.432	0.574	0.348	0.428	0.660	0.529	**0.711**	0.803	0.506	0.436

Notes: n = 244.

The square root of AVE on diagonal in boldface.

CR: Construct Reliability; AVE: Average Variance Extracted; MSV: Maximum Shared Variance

Table 6.3 provides first-order inter-construct correlations, reliability and discriminant validity of all constructs. The square roots of AVEs are indicated daagonally in Table 6.3, and all these values are greater than the construct correlations and thus satisfying the condition for reasonable discriminant validity. The composite reliabilities of all constructs are above the acceptable standard of 0.70, except for only one construct ‘process management practice’ as shown in Table 6.3 shows good construct reliability (Fornell and Larcker, 1981).

6.6 MODEL FIT

The fit indices of the measurement model are evaluated and tabulated in Table 6.4. The fit indices such as chi-square (χ^2), ratio of chi-square to degrees of freedom (χ^2/df), goodness of fit indices (GFI), Normed fit index (NFI), Incremental fit index (IFI), Tucker-Lewis Index (TLI), and Comparative Fit Index (CFI) were used for the evaluation of the measurement model. In addition to these absolute fit indices, namely, Root mean square error of approximation (RMSEA) and Root mean square residual (SRMR), were also used for evaluation of model fit. No strict guidelines are defined to follow to represent an acceptable fit (Schermelleh-Engel et al., 2003). However, several parameters are evidenced from various references and academic works

Table 6.4 Model Fit Indices of Measurement Model

Model Fit Statistics	**Recommended Value**	**Model Value**
Chi-square	-	495.316
df	-	322
Chi-square Ratio	< 5.000	1.538
GFI	>0.8 marginal fit >0.9 good fit	0.880
NFI	>0.8 marginal fit >0.9 good fit	0.838
IFI	>0.8 marginal fit >0.9 good fit	0.937
TLI	>0.8 marginal fit >0.9 good fit	0.924
CFI	>0.8 marginal fit >0.9 good fit	0.936
RMSEA	≤ 0.08 marginal fit ≤ 0.05 good fit	0.046
SRMR	< 0.1 marginal fit < 0.05 good fit	0.053

For Small sample sizes, GFI and NFI, are often underestimated and hence the measurement models can good fit indices with the exclusion of these two indices (Byrne 2010; Kline 2005). According to Shah and Goldstein (2006) CFI, TLI, and IFI are considered fit measures for small sample sizes. The values of GFI, NFI, TLI, CFI, and IFI with close to 1.0 or greater than 0.9 represents a good fit (Byrne, 2010; Kline, 2005). According to Byrne (2010), an RMSEA value of less than 0.08 is reasonable, and a value of 0.05 or less indicates a good fit. According to Schermelleh-Engel et al. (2003) and Kline 2005, an SRMR between 0.05 and 0.10 is considered favourable.

Table 6.4 gives the goodness of fit for our model (χ^2=495.316, χ^2/df=1.538, GFI=0.880; NFI=0.838; IFI=0.937, TLI=0.924; CFI=0.936, RMSEA=0.046; RMR=0.053). All these fit indices are within the recommended values for model fit. Hence the overall fit of the model is acceptable and thus supporting the unidimensionality and convergent validity of all dimensions.

6.7 STRUCTURAL MODEL RESULTS

The structural model developed by path diagram is shown in Figure 6.4. In this path diagram, significant relationships between the constructs are represented by the straight arrows between the constructs. These arrows represent the six hypotheses (H1 to H6). Maximum likelihood estimation (MLE) was used for the analysis of this structural model.

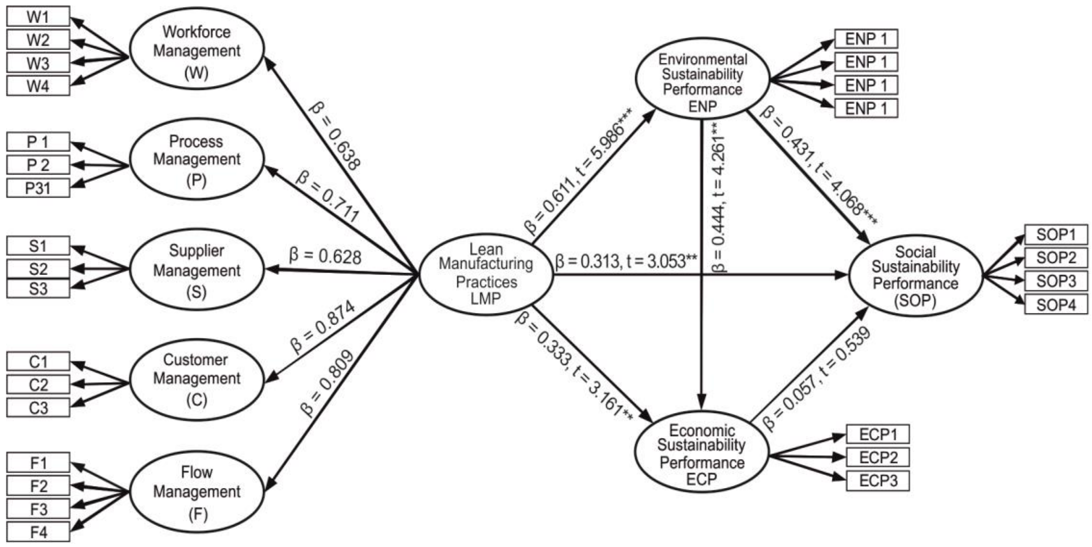

Figure 6.4 Structural Model

The model fit statistics are evaluated from the output of SEM analysis in IBM AMOS 21and shown in Table 6.5.

Table 6.5 Model Fit Indices of Structural Model

Model Fit Statistics	Recommended Value	Model Value
Chi-square	-	538.967
df	-	339
Chi-square Ratio	< 5.000	1.590
GFI	>0.8 marginal fit >0.9 good fit	0.869
NFI	>0.8 marginal fit >0.9 good fit	0.824
IFI	>0.8 marginal fit >0.9 good fit	0.927
TLI	>0.8 marginal fit >0.9 good fit	0.917
CFI	>0.8 marginal fit >0.9 good fit	0.926
RMSEA	≤ 0.08 marginal fit ≤ 0.05 good fit	0.048
SRMR	< 0.1 marginal fit < 0.05 good fit	0.061

The chi square value, degree of freedom and Chi square ratio of the model were evaluated. From Table 6.5, the chi-square ratio of the model is 1.590, which is within the limit of maximum value five. The fit indices, namely, GFI, NFI, IFI, TLI, CFI, were found to be above the minimum values for marginal fit or good fit. The RMSEA value is within the limit for good fit and SRMR values is within the limit for moderate fit.

The results of the SEM with standardised regression coefficients and t values are evaluated. The details of the hypothesis and the corresponding p-values obtained are shown in Table 6.6.

Table 6.6 Results of the Structural Models

Relationship	*Hypothesis*	*Standardised Regression Coefficient (β)*	*t value*	*P value*
LMP--> ENP	H1	0.611	5.986	0.000***
LMP--> ECP	H2	0.333	3.167	0.002**
LMP-->SOP	H3	0.313	3.053	0.002**
ENP-->ECP	H4	0.444	4.261	0.000***
ENP-->SOP	H5	0.431	4.068	0..000***
ECP-->SOP	H6	0.057	0.539	0.590

Notes: N=252

***, **, * indicates the significance of the p-value at < 0.01, 0.05, and 0.10 respectively.

From the Table 6.6, the hypothesis H1, LMPs enhance environmental sustainability performances is accepted. The estimated coefficient of $\beta = 0.611$ ($t = 5.986$, $p< 0.01$) for the relationship between lean manufacturing and environmental sustainability performances is significant indicating strong support for hypothesis H1. This finding is in line with prior study conducted by Yang et al., (2011).

The hypothesis H2, LMPs enhance economic sustainability performances is also accepted. The estimated coefficient of $\beta = 0.333$ ($t = 3.167$, $P< 0.05$) between lean manufacturing and economic sustainability performance significantly supports H1.This outcome is consistent with the extant literature (Fullerton and Wempe, 2009; Shaw and Ward, 2003).

The hypothesis H3, LMPs on social sustainability performances is also accepted. The proposed relationship between LMPs and social sustainability performance is supported with an estimated coefficient of $\beta = 0.313$ ($t = 3.053$, $p < 0.05$).

The estimated coefficient of $\beta = 0.444$ ($t = 4.261$, $p < 0.01$) for the relationship between environmental sustainability and economic sustainability performances is significant representing a strong support for hypothesis H4. This finding is similar to prior works. Similarly, the proposed relationship (H5) between environmental sustainability and social sustainability performance is supported by an estimated coefficient of $\beta = 0.431$ ($t = 4.068$, $p < 0.01$). However, the structural equation results show that the proposed relationship between economic sustainability and social sustainability performance is insignificant with an estimate coefficients $\beta = 0.057$ ($t = 0.539$, $p > 0.10$).

6.8 CONCLUSION

The study explains whether LMPs influence sustainability performances in MSMEs or not. The findings reveal significant positive effects of LMPs on three dimensions of sustainability benefits – economic, environmental, and social sustainability performances (H1-H3). These results give the evidence that LMPs are valuable resources for achieving the sustainability. The study also agrees with the vast majority of the literature, which indicated a positive relationship between the agreement of LMPs and performances of the organisations (Chugani et al., 2017; King and Lenox, 2001; Ball, 2015; Longoni et al., 2013).

The positive relationship of LMPs and economic and environmental performances are already established from the previous works (Rothenberg et al., 2001; Ng et al., 2015; Fullerton and Wempe, 2009; Ball, 2015; Yang et al., 2011), which this study further confirms in MSMEs. The findings acquire greater significance, as India is one of the developing countries in which MSMEs are playing a crucial role, and government authorities are promoting LMPs. The findings in this research work are crucial and relevant than the earlier works conducted in this field precisely because LMPs also have a positive link toward the social benefits.

The LMPs focus on the “people” in addition to “profit” and “planet” with particular attention given to the welfare of workers including safety and health, labour relationship, and customer satisfaction. Hence, adopting LMPs in the manufacturing MSMEs and thus becoming leaner in its operations is one of the ways to achieve business sustainability. This finding is in line with the recommendations of Thomas et al. (2012).

The interrelationship between the 3BL sustainability performances and their linking with each other were also tested (H4-H6). Consequently, significant positive effects on environmental sustainability to economic and social sustainability performances (H4 and H5) are established from this study which is in line with the findings of the previous study by Vinodh and Joy (2012). Further, this study shows that there is no a significant relationship between economic and social sustainability performances (H6). This finding becomes significant as the attainment of the economic sustainability may not guaranty the social sustainability.

Moreover, this result is a clear indication of the conflict of interest of organizations (Wong and Wong, 2014) that have been existing among the entities of sustainability, giving more emphasis on profit without much consideration to people. MSMEs often lag behind on the implementation of best practice including LMPs and sustainability practices (Panizzolo et al., 2012; Thomas et al., 2012; Zhou, 2012; Urban and Naidoo, 2012; Upadhye et al., 2013). MSMEs have different reasons for this situation which are resource constraints, managements inability to adapt to changes, and unwillingness to make the necessary investments for the lean implementation (Zhou, 2012; Theyal and Hofmann, 2012; Panizzolo et al., 2012). The findings of this study corroborate the necessity of adoption of LMPs within the MSMEs, targeting their sustainable growth.

CHAPTER 7
CASE STUDIES

7.1 INTRODUCTION

Studies that link the use of LMPs and the sustainability performance have already been discussed in the earlier chapters. The SEM analysis tested the different hypotheses in connection with the relationship of LMPs and three dimensions of sustainability performance. From this above study, it was statistically proved the existence of a significant positive influence of LMPs on the sustainability performance of MSMEs.

A case study is a research method involving close, in-depth, and detailed examination of the subject of an investigation known as cases, as well as its related contextual conditions (Robert, 2014). This method applies to contemporary events in which there are no control behavioural variables (Yin, 1993). In this study, we selected case study method to the in-depth and closer investigation of the effect of LMPs on sustainability performance. This chapter is committed to the presentation of five cases that were conducted in different industries. The selection of these cases was made to cover the range of key operational factors that influence LMPs including the size of the firms, type product, sector, and manufacturing process, etc.

The case studies that link the LMPs with the sustainability performance conducted for validating the results of statistical studies are presented in this chapter. The selected cases deal with the organisations in which the use of LMPs is done at different levels. The case studies are used to support and clarify the hypotheses tested. The chapter ends with the conclusion and the suggestions to improve the firm's sustainability performance through better use of the LMPs.

7.2 THE OBJECTIVES OF THE CASE STUDY

The case studies were conducted to fulfil the following objectives:

To observe and understand the pattern of the use of LMPs, sustainability performance, and other measures.

1. To compare the firms use of LMPs with the findings of the research model.

2. To examine the nature of the linkage between the use of LMPs and the firm sustainability performance.

3. To suggest methods to improve the use of LMPs and the firm performance.

7.3 THE CASE STUDIES

LMPs followed in the five manufacturing firms are presented in the five cases. The sustainability performances of the firms are also examined and presented. Operating system characteristics such as product type, the nature of the business, investment level in plant and machinery, number of employees, the level of profit and nature of the manufacturing process are considered during the selection of the firm for this case study. Characteristic features of these MSMEs included in the cases are shown in Table 7.1.

Table 7.1 Characteristic Features of the MSMEs Included in the Case Study

Firm	Product	Nature of Business	Level of Investment in Plant & Machinery	Number of Employees	Level of Profit	Nature of Manufacturing Process
Firm A	Cattle Feed	Make to stock. ISO 9000	Medium	300	High	Flow
Firm B	Paint	Make to stock ISO 9000, ISO 14000	Medium	220	Low	Flow
Firm C	Heavy Electrical equipment	Make/assemble to order, ISO 9000	Small	>50	Medium	Job shop
Firm D	Plastic products	Make to Order	Small	< 50	Medium	Batch
Firm E	Paper Products	Make to order	Micro	20	Medium	Batch and Jobshop

The details required were collected by personally visiting the selected firms. Face to face interviews was conducted at different organisational levels, including owners, managers, and supervisors and shop floor employees. The documents that are permitted by the companies were also referred to the information collection and better understanding of the working levels of the firm. In addition to personal interviews and document references, the same questionnaire which was used for the survey in the previous chapters was used to get the responses from the companies. Information from multiple levels and archival data were helpful to cross-check and verify the reliability of data (Yin, 1993). The LMPs which have been followed by the firms and the sustainability performances achieved in the last three years were carefully examined in depth. Major problems or limitations of LMP usage in each case are found, and the solutions are proposed, to improve the performance. A cross-case comparison was also made to identify general requirements and guidelines to satisfy MSME needs.

7.3.1 CASE STUDY OF THE COMPANY A

The company A is a medium scale industry engaged in the manufacture and distribution of cattle field, and dairy products. This study was conducted in the cattle field unit of the firm. This unit started production in 1976 and now became the largest cattle field producer and supplier in Kerala, India. It produces seven types of cattle feed with three in mash form and four in pellet form. Now the company is predominantly a cattle feed producer with about 75% of its revenues coming from the sales of cattle feed with a sales volume of 440,000 metric tons by financial year 2014-15. It has a fully automated process plant with computerized feed formulations. The centralised online quality checking of the product is possible at every step of the production process so that the final product can be dispatched directly from the plant. This facility helps to avoid the additional waiting and stacking of the products for quality inspection. The total number of employees in the plant for the round the clock operations are around 300. The company has a competitive business environment with a flat level of demand. The company is an ISO 9000 certified one.

The company has an agreement with the workers with the involvement of trade unions to strict adherence to the fixed volume of production. As the demand for the product is more than the daily production, the situation is not generating the overproduction or inventory of finished goods. At the initial time, the utilised capacity of the plant was 240 Tons/day. The company could effectively implement lean principles and avoid the situation of under utilisation of resources by fixing the plant output to 440 Tons /day. This increase in the daily production was achieved by the nominal increase in the workforce and renovation of the old plant with capacity 100 tons /day. No additional investments were made in all other facilities and or increased overhead expenses, which enhance the effective utilisation of resources.

Being a process industry, the setup time reduction has not gained much attention. The layout of the plant is well designed, but the layout is not much influenced by inventory levels. The company management and workforce are following 5S principles. The company has SOPs and follows the documentation of processes. The instructions are displayed in the local language, which makes easy to communicate with every level of employees. The company follows both preventive and predictive maintenance. It regularly conducts customer surveys to get the feedbacks. Once in a month, marketing division analyses the sales reports and customer feedbacks which are also according to the requirements of ISO standards.

Customer complaints are very seriously attempted by the company and products are replaced according to the severity of the complaints on. Supplier relationship is well maintained by better payment strategies of 90 percent payment on the day of arrival after stricter quality checks. Around 95 percent of the raw materials are agriculture materials, and hence the JIT supplier concept is not truly applicable. The quality analysis reports made available for suppliers to take the corrective actions

As part of the discussion, all team members' opinions are collected before the decisions. Between shift changes, feedbacks are recorded by the employees and this information are effectively communicated to following employees in next shift. No separate maintenance department is functioning in the company. The workforce attitude, the influence of trade unions and the resistance to change are the barriers identified for the lean implementation in the firm.

Table 7.2 Case Study in Company A

LMPs that improve sustainability	Operational-advantages	Sustainability advantageous	Barriers to implementing lean manufacturing
• 5s principles • Work standardisation. • Preventive and predictive maintenance • Measure of customer satisfaction • Supplier relationship • Employee involvement • Self-directed work teams • Quality at the source • Continuous improvement	• Production Efficiency • Competitive pricing • Product quality, Product performance • Speed of delivery • Capacity to change products' volume • Flexibility to change from one product to another	• Profit • Low inventory cost • Reduction in Emission • Reduced accidents • Better safety and health • Better labour relationship • Employee training and education • Reduced rate of customer complaints	• Workforce attitude • Trade union • Resistance to change

The Table 7.2 provides the tabulation of LMPs in the company-A and the corresponding operational advantageous, sustainability advantages and barriers to implementing LMPS. Table 7.2 shows that against the different LMPs, company have multiple noticeable sustainability performances in economic, environmental and social dimensions of sustainability.

7.3.2 THE CASE STUDY OF THE COMPANY B

The company B is a paint manufacturing company engaged in the manufacture of all types of paints including enamel paints, emulsion putty, wood coatings, and strainer. The company is more than 25 years in this field with a total number of 220 employees. It has a competitive business environment with competition from multinational and local paint manufactures. It holds the fifth position regarding turnover among paint manufacturing industries in India. It is following make to stock strategy to meet the demand in the cycle. The company is an ISO certified company following ISO 9000, ISO 14000 and OHSAS. The company's layout is that of flow production. Recently, it had a change in management and has been modernised and expanded to increase the capacity.

The company has maintained its work in process inventory as low as possible and cautious to stick on to the daily production schedule. The two new machines were installed achieving a high rate of production, and the firm followed proper scheduling practices. The centralised procurement system is followed in all divisions of the company. As the raw material suppliers are not located nearby, the company could not follow JIT delivery of raw materials by the suppliers. The company is further planning to modify the plant layout to minimise the inventory and facilitate a faster throughput. Through a proper material requirement planning (MRP), the company maintains the inventory level to a minimum. Maintaining a proper supplier relationship is the policy of the company, and strict quality checks are followed before taking the materials in stock.

The company follows 5S principles and OHASIS which insist on putting all tools and accessories in proper places. SOPs are displayed in visual boards kept in relevant positions in the plant making it visible to everyone. The preventive maintenance is adopted and preventive maintenance schedule is strictly adhered. Customer satisfaction is regularly measured by conducting surveys among the dealers and end users. From the results of this survey analysis, the customer needs are identified which are communicated to all employees. The workforce is convinced of the necessity of taking proper steps to resolve the customer complaints. The company has a toll free number to register complaints by the end users. If a complaint is registered, a technical person visits the customer site and takes the necessary steps to resolve the issue. If the complaint is due to the quality of the product, that product will be replaced at the expense of the company for the satisfaction of the customers.

Table 7.3 Case Study in Company B

LMPs that improve sustainability	Competitive advantageous	Sustainability advantageous	Barriers to implementing lean manufacturing
• 5 s Principles • Work standardisation • Total Productive Maintenance • Preventive and predictive maintenance • Measure of customer satisfaction • Supplier relationship • Employee involvement • Continuous improvement	• Product quality • Product durability • Speed of Delivery • Production flexibility	• Growth in market value • Green image • Reduction in Emission • Safety and health • Reduction in Material usage • Decrease rate of consumer complaints • Labour relationship	• The influence of trade unions • The fear of employees • Centralized procurement • Lack of local suppliers of raw materials

The Table 7.3 provides the tabulation of LMPs in firm B and the corresponding operational advantageous, sustainability advantages and barriers to implement LMPS. The sustainability performances in economic, environmental and social dimensions shown in table 7.3 achieved by the firm against the different LMPs are the indication of the significant relationship between these variables.

7.3.3 CASE STUDY OF THE COMPANY C

Company C is involved in the manufacture and supply of components of heavy electrical equipment such as transformers and switchgear. Product list includes resin cast current transformers, epoxy resin casting, resin cast potential transformers and low tension current transformers in various specifications. This company has been manufacturing these products for more than 20 years. It has acquired a good reputation among the electrical consultants, contractors and industrial establishments from its inception. The client list includes government organisations in power sector, water supply, railway and nationalised banking. Client list also includes builders, hospitals, and a lot of major industries in India and abroad. The products are also being exported to the Gulf countries. It operates in a highly competitive business environment with a level demand for products and follows make to order strategy. A key person in the firm is a women entrepreneur, having more than 15 years of experience in the field of manufacturing. The factory has a total area of 8000 sq. feet, well-equipped production facilities having latest machinery, material handling facilities, and testing labs. It is an ISO 9001 certified company and committed to provide good quality products.

Table 7.4 Case Study in Company C

LMPs that improve sustainability	Competitive advantageous	Sustainability advantageous	Barriers to implementing lean manufacturing
• Setup time reduction • Adherence to daily schedule • Layout size and shape, • 5s principles • Work standardisation. • Customer Involvement • Customer satisfaction • Supplier relationship • JIT delivery by suppliers • Employee involvement • Self-directed work teams • Quality at the source.	• Production Efficiency, • Product quality, Product performance, • Speed of delivery • Capacity to change products to a specific customer need • Capacity for building different products at a time, • Flexibility to change from one product to another	• Profit • Reduction in Emission, • Savings in material usage, • Energy savings, • Reduced accidents, • Better safety and health, • Better labour relationship, • Employee training and education, • Reduced rate of customer complaints	• Thought of relatively less wastage among the top management • Resistance to change and adapt innovations. • Unavailability of competent consultants. • The difficulty in for getting grants announced by the Govt.

The company faces challenges in manpower management, availability of suitable and sufficient human resource, marketing, and fierce competition from local markets. Management is trying to adopt cost-cutting in all the stages of the production process, to make the products competitive in the market.

The company has been following 5S principles. The toolboxes are provided to keep the tools and other accessories and have given instructions to keep in the proper place. At the same time keeping all sections in the factory clean is firmly followed. Adherence to the daily schedule is strictly followed, which is reflected in the timely delivery and the customer satisfaction. The setup time reduction techniques are used in all sections except some of the automated machines.

The company is promoting the involvement of employees and motivate them to be a self-directed workforce. The layout of the company is well designed to minimise the unwanted movements. The customers are allowed to visit the plant to understand the manufacturing processes to give suggestions. At the same time, company executives are giving services voluntarily to client companies in technical areas. A particular emphasis on long-term supplier relationship is maintained by the timely payments, information sharing, and providing technical assistance. This also enables the on-time delivery by the suppliers and quality checks at supplier edge.

Table 7.4 provides a tabulation of LMPs in company C and the corresponding operational advantageous, sustainability advantages and barriers to implement LMPS. On examining the sustainability advantages achieved by the firm shown in the table gives the performance measures in economic, environmental and social dimensions of sustainability.

7.3.4 CASE STUDY OF THE COMPANY D

The company D is engaged in the manufacturing of plastic injection moulded products. The company also have a parallel unit for fabrication of metallic mould and dies for the plastic injection moulded industries. The company was started in the year 2004 and is providing the services for the similar other companies in the area of die related works. The products are made according to the order from customers. Plastic products are produced in batches, and the die making is run as a job shop. The company D has a total of fewer than 50 employees. Based on the level of investment in plant and machinery; the firm is categorised as a small enterprise. It has a competitive business environment. It has invested in the implementation of lean practices, and top management is continuously monitoring the benefits of lean implementation.

Table 7.5 Case Study in Company D

LMPs that improve sustainability	Competitive advantageous	Sustainability advantageous	Barriers to implementing lean manufacturing
• 5S • Work standardisation. • Total Quality Management, • Quality at source, • Supplier relationship, • Total Productive maintenance, • Supplier relationship, • Employee involvement, • Continuous improvement, • Self Directed work teams	• Product quality • Product Durability • Manufacturing lead time • Speed of delivery • Capacity to change production volume • Build different products at a time	• Low operational cost • Profit • Growth in market value • Reduction in material usage • Reduction in Emission • Labor relationship • Decrease rate of consumer complaint • Training and education • Growth in market value • Safety and health	• Availability of skilled workers and unskilled workers locally. • Price Fluctuations of raw materials in connection with Petroleum products. • Lack of local suppliers of raw materials • Limitation in the existing raw material bank/ mould bank • Difficulty in maintaining the LMPs in the long run. • Multiple projects by management

In the plant, separate cupboards have been provided for storing tools and other accessories. Operators strictly adhere to the practice of keeping these items in their proper place so that it is easily accessible to everyone. The SOPs are followed in operations and well communicated to the workforce. Hence it is not displayed at the plant. The company has signed MOUs with major suppliers of raw materials. Emphasis has been given to the timely payment to suppliers to keep the trust of the suppliers. The company thinks that the employee suggestion scheme is a more efficient method to resolve the quality problems. Customers are permitted to visit the plant and to give their feedback. Similarly, management team frequently visits the outlets and customers to get the feedback Employees are motivated for achieving their targets. The layout of machines and equipment was not effective, hence, with the help of experts, the layout was redesigned for and improved performance. Even after the redesign, the company expects a more improved design of layout for better performance.

The company is procuring raw materials in bulk quantities, as most of the suppliers are from outside the state.So rate discounts are received from the suppliers. Modernised machines implemented to reduce the energy consumption and reduce the emission. Periodic meetings of employees are arranged in which opinions of employees are recorded. Implant training is organised for all employees for their empowerment. Particular attention is provided for the safety of the workforce.

In spite all these efforts, the company face some barriers to the implementation of LMPs. Nonqualified employees, outside state employees and multiple projects run by management at the same time are some of the big barriers of the firm to LMP implementation.

Table 7.5 provides the tabulation of LMPs in company D and the corresponding operational advantageous, sustainability advantages and barriers to implement LMPS. This table shows that against the different LMPs following the company have multiple noticeable sustainability performances in economic, environmental and social dimensions of sustainability

7.3.5 CASE STUDY OF THE COMPANY E

This company is engaged in the manufacturing of paper products and related service activities. The company started in the year 2010 and with an authorised capital of Rupees less than 50 lakhs. As per the classification of MSME act 2006, it is coming under the micro scale enterprise. The number of employees is twenty. The company has installed latest machines and has been giving training to employees on these machines. It has a cyclic demand for the products and works according to make to order strategy. The customers of the firm include the government and public sector organisations as well as many private organisations in the region. In the initial stage, the company faced fierce competition from local MSMEs and struggled to sustain in the market.

Due to the increased competition from the similar firms, and to survive in the business, the company adopted continuous improvement and suitable managerial, operational practices to improve the outputs and performances. The company has a keen focus to waste reduction and optimum use of resources. It has adopted the best practices in supplier and customer management. The company is trying to reduce the setup time for the tools and workstations. Occasional failures in meeting the daily production schedule occur due to operational delays. The company is finding difficult to maintain the work in process inventory to the minimum level. The company is following the documented and standardised processes for daily operations and effectively circulated this information to the workforce. The workers themselves carry out the routine maintenance of all equipment, and no separate maintenance staffs are appointed.

The company focuses on maintaining a good relationship with their customers, workers, and suppliers. However, the relationship with suppliers is not up to the mark. So the company has taken steps to build a closer relationship with suppliers and now sharing more information on demand with the suppliers. The workers are the strength of the firm, and the firm effectively practices employee involvement. For important decision making, employees'opinions are playing a major role, and small group sessions with employees are conducted for solving the issues. Even though the operational cost is found to be little high, market growth of the company is in a good position. The company identified the nonvalue-added activities at the various levels of operations, but the reduction of these nonvalue-added activities are not effective. The reduction in material usage, pollution, emission, and energy are marginal. However, in social aspects, the company could achieve benefits in the areas of labour relationship, safety and health.

Table 7.6 Case Study company E

LMPs that improve sustainability	Competitive advantageous	Sustainability advantageous	Barriers to implementing lean manufacturing
• 5S • Work standardisation. • Total Productive maintenance • Supplier relationship, • Employee involvement, • Continuous improvement	• Fast deliveries • Low cost • Quality • Product performance	• Low operational cost • Profit • Reduction in Material Usage • Reduction in Energy	• Lack of Skilled labours • Lack of Vision • Poor infrastructural facilities

Table 7.6 provides the list of LMPs in company E and the corresponding operational advantageous, sustainability advantages and barriers to implementing LMPS. Table 7.6 shows that the company D is following a less number of LMPs compared to other companies and the corresponding number of sustainability performances are also less. Lack of skilled labours, lack of vision and poor infrastructural facilities are the barriers for the firm in implementing the LMPS.

7.4 CROSS CASE EVALUATION OF CASE STUDY OBSERVATIONS.

A comparison of the performances of all companies considered, for which the five cases mentioned above have been cross-analysed. The benefits attained by the five companies in various categories are collected qualitatively by adopting LMPs are tabulated in as shown in Table 7.7. All the sustainability performances are listed in this table, and the corresponding degrees of improvements are posted against each performance measure.

The degree of improvements of each firm against each performance indicators are recorded as ‘significantly improved’, ‘improved’ and ‘no improvement’ based on the sustainability benefits achieved by the firm. In the Table 7.7, the corresponding to the ‘no improvement’, the cells are kept blank. From this table, it is clear that all the five firms have attained significant sustainability performances through the implementation of LMPs.

Table 7.7 Cross Case Evaluation of Case Studies

Sustainability Performances	**Company A**	**Company B**	**Company C**	**Company D**	**Company E**
Reduction In operational Cost	Improved Significantly	Improved	--	Improved Significantly	Improved
Profit	Improved significantly	-		Improved Significantly	Improved
Growth in Market Value	Improved significantly	Improved Significantly	Improved Significantly	Improved Significantly	-
Reduction in environmental business wastage	Improved significantly	Improved significantly	Improved	Improved	
Reduction in Emission /unit of Production	Improved significantly	Improved significantly	Improved significantly	Improved Significantly	Improved
Reduction in Material Usage/ Output	Improved		Improved significantly	Improved Significantly	Improved significantly
Reduction in Energy/ Fuel usage	Improved		Improved	Improved	Improved significantly
Safety and Health	Improved		Improved significantly	Improved Significantly	-
Labour relationship	Improved	Improved significantly	Improved	Improved Significantly	-
Training and Education	Improved	Improved significantly		Improved Significantly	-
Decrease in Rate of consumer	Improved	Improved significantly	Improved significantly	Improved Significantly	Improved

7.5 CONCLUSION

The five case studies presented above show how the sustainability performances of the manufacturing firms are improved by the adoption of lean manufacturing practices. The Companies A and B are medium-sized enterprises having flow type production processes and were following LMPs to a great extent. Company A is an ISO 9000 certified organisation while B is ISO 900O and ISO 14000 certified organisation. The company A has implemented various practices, including workplace organisation and continuous improvement and has achieved sustainability performances. The benefits achieved include improved profit, reduction in cost, better safety and reduced emission which are the three constructs of the sustainability performance. The company B has implemented a slightly less number of LMPs, and achieved sustainability performance measures are also less than that of company A.

Company C is a small scale organisation following more practices than the companies A and B. On examining the performance measures; it can be observed that company C is in an advanced stage than company A and B. The company produces job products with ISO 9000 certification in assemble to order system. It is effectively followed the setup time reduction and self-directed work teams at various levels. At the same time, it is also facing barriers to lean implementation such as negligence of the importance of waste reduction, resistance to change, unavailability of competent consultants and funds.

The company D is also following more LMPs than A and B and indicate good sustainability performance achievements. The Company D is from the plastic sector, producing two types of products with less than 50 employees. The company has good records in lean practices, and the management and employees are much familiar with these practices. It gives much emphasis to workplace organisation, SOPs and supplier management practices and has good performance records in economic, environmental and social dimensions. The company is facing different barriers such as non availability of skilled labours and the issues related to raw material availability. However, along with this limitation also, the company has a great affinity to LMPS and have gained better sustainability outcomes.

The company E is a micro scale firm in the paper sector, having low investment in plant and machinery and less number of employees. This firm has an affinity for a less number of practices than other companies do and the corresponding benefits earned in performance measures are low. This company has different barriers to the lean implementation such as lack of vision, skilled labours and infrastructure facilities.

All the findings stated from the above case studies are supporting the inferences derived from the testing of the hypotheses in the earlier chapter. The positive influences of LMPs towards the economic, environmental and social dimensions are validated from these case studies. The study also exposed the barriers and specific issues of the case companies towards the lean implementation. These barriers should be addressed for the betterment of the firms as well as the industrial development of an economy.

CHAPTER 8
THE SUMMARY AND CONCLUSIONS

8.1 INTRODUCTION

The lean practices followed by organisations worldwide have helped to improve the operational and sustainability performances, especially in the large-scale organisations. Multiple studies have been conducted in different countries for bringing out the benefits of lean practices. This research was aimed to identify the effect of the LMPs on the sustainability performances of manufacturing MSMEs. The research also focused on identifying the areas of linkage between lean and sustainability and the effect of operating system variables in these areas. To address these aims, initially a thorough literature review was conducted in the subject area and a descriptive research was designed. The constructs and variables for the dependent and independent variables were selected from the previous works. The relevant hypotheses were developed based on the objectives and literature available.

An exploratory survey was conducted by using a questionnaire generated out of the variables identified. The data collection was restricted to the sample frame selected as per the research framework and design. The data were collected from 252 manufacturing MSMEs from Kerala, India and was analysed using various statistical methods. like descriptive analysis, one sample T test, Kruskal Wallis-Chi square test, EFA and SEM, The SEM was conducted to identify the significant effect of LMPs on various dimensions of sustainability performances and the interrelationship between these performance measures. Finally, the test results were cross validated and analysed with five case studies selected from the same sample frame.

This chapter presents the main research findings from the study about the aim and objectives of this study. It also provides the limitations of this study and the directions for the future research. The chapter ends with the conclusions and recommendations arising from the research findings.

8.2 THE FINDINGS FROM THE STUDY

This study analyses the adoption of LMPs in Indian MSMEs. The descriptive analysis of the exploratory survey helps to understand the degree of intensity of adoption of lean practices in Indian MSMEs with a focus to identify the most used lean practices. This analysis shows that that MSMEs in the considered region are noticeably following lean principle. The results of the study reveal the followings.

- From the descriptive analysis, maintaining the long-term supplier relationship and customer focus are the two most important lean aspects followed in MSMEs. The 5S principle which emphasise to keep the tools and fixtures on the proper palace and JIT delivery by suppliers are the two other mostly followed LMPs in MSMEs.

- Lean operations have a wide range of areas in which it can be integrated into the concept of sustainability, beyond waste reduction and environmental management. Other areas of linkage between lean and sustainability in MSMEs include quality, health and safety, continuous improvement, worker empowerment, performance improvement, value maximization, resource management, cost reduction, supply chain management, transparency, energy minimisation, community strategy and governance.

- The study identified the waste reduction is the most important area of linkage between lean and sustainability in MSMEs. Quality and health and safety are the other important areas of linkage between the lean and sustainability.

- The respondents classified based on the level of investment are statistically different in the areas of linkages between lean and sustainability. This result indicates that these firms classified based on the level of investment have different important areas of linkages between lean and sustainability. Hence separate detailed studies are required on the different investment levels for the better understandings on the applicability of both these concepts.

- The respondents classified based on different manufacturing sectors have no statistical difference in the areas of linkages between lean and sustainability. This result is a clear indication for policymakers to frame common policies to all manufacturing sectors independent of the product type.

- The grouping variables, namely the manufacturing process based on job shop, batch production, and flow shop and production system based on make /assemble to stock and make /assemble to order causes a partial statistical divergence among the respondents on the linkages between lean and sustainability. These results indicate the need of detailed studies, in each categorisation of respondents to draw more accurate inferences on the integration of lean operations and sustainability.

- The factor analysis conducted on 19 variables of lean manufacturing practices shows that LMP in MSMEs can be grouped into five significant factors. These factors include flow management practices, process management practices, customer management practices, supplier management practices and workforce management practices.

- The descriptive statistics show that the most relevant construct in the LMP is ‘supplier management practices' and the least dominating construct is ‘workforce management practices’ This result indicates that MSMEs have been emphasing on supplier management by building long-term relationship and high level of information transparency or sharing with their suppliers.

- Based on the factor analysis the sustainability performances in MSMEs can be categorised into three constructs as "economic sustainability performance," "environmental sustainability performance" and "social sustainability performance". The social sustainability performance explains the major share of variance explained by Sustainability performance.

- Labour relationship, safety and health, and decreases in the rate of customer complaints are the most important sustainability performances from lean practices. This is a clear indication of the social relevance of LMPs in the manufacturing MSMEs.

- The SEM analysis provides a solid basis for the link between sustainability and lean implementation in MSMEs and the interlink of sustainability performances. Findings reveal significant positive effects of LMPs on the three dimensions of sustainability performances of MSMEs namely economic, environmental, and social sustainability performances. These results corroborate that LMPs are a valuable means for achieving sustainability.

- There is a positive relationship of LMPs and economic and environmental performances in MSMEs. This result is in line with the findings from previous works (Rothenberg et al., 2001; Ng et al., 2015; Fullerton and Wempe, 2009; Ball, 2015; Yang et al., 2011).

- The LMPs focus on the “people” in addition to “profit” and “planet” with particular attention given to safety and health, labour relationship, training and education and customer satisfaction. The findings in this research work are important and relevant than the earlier works conducted in this field precisely due to a positive link of LMPs toward the social benefits

- Adoption of LMPs is one of the ways to achieve sustainability in manufacturing MSMEs This finding is in line with the recommendations of Thomas et al. (2012).

- The study tested the interrelationship between the 3BL sustainability performances and their linking with each The study shows that there are significant positive effects of environmental sustainability to economic and social sustainability performances in manufacturing MSMEs.

- The study shows that there does not exist a significant relationship between economic and social sustainability performances in manufacturing MSMEs. This finding indicates that the attainment of the economic sustainability may not guarantee the social sustainability.

- The study clearly indicates that conflict of interests of organisations (Wong and Wong, 2014) have been existing in manufacturing MSMES among the entities of sustainability, giving more emphasis on profit without much consideration to the people.

8.3 LIMITATIONS OF THE STUDY

Since this work leads to theory and practice, it has the following limitations that will need to be considered in the future works. The respondents of this study were from a particular state in India and hence the sampling frame of the study was limited. Hence, to generalise in global scene, it is required to conduct similar studies in other economies of the different countries.

Another limitation of this study is that the responses obtained are views of a single respondent representing their respective organisation as a whole. There might be dissenting views among respondents within the same organisation. Hence, the results cannot be extrapolated entirely to the global MSME landscape. The survey uses a cross-sectional data collection framework, and this limit from obtaining a longitudinal inference. The cross-sectional survey designs adapted for this study limit the derivation of causal inferences. This study did not consider audited information on the 3BL positions of the organisation during the survey, which prevented the use of, results on sustainability indicators from crossing reference with actual audited statements.

In future researches, the outcomes of the present research need to be externally validated in other emerging economies in the world. The replication and extension of the same work in the other economies will give the basis for the external validation of the finding. The results are also needed to be validate by conducting case studies in various manufacturing sectors before generalisation. Empirical study with multiple respondents from every organisation in the longitudinal time frame will give more robust and accurate inferences.

8.4 CONCLUSION

The present study postulates the role of lean manufacturing as a powerful tool to gain the sustainable advantages in the MSMEs. The results of the study provide a solid basis for the link between sustainability and lean implementation in MSMEs and the interlink of sustainability performances. The study summarises the positive effect of LMPs toward the three dimensions of sustainability performance and the positive effect of environmental sustainability on economic and social sustainability performances. It also highlights the insignificant effect of economic sustainability on social sustainability. The outcome of this study is relevant to the academic community as well as the practitioners. It gives a crucial perceptive of the importance of the LMPs on the sustainability performance of MSMEs. These results provide an insight and important insinuation for decision-makers in developing and implementing lean strategies in this sector.

This study has made a significant contribution to the theoretical development of the effect LMP has on social performances in addition to economic and environmental benefits. These findings greatly equip the managers to implement LMPs in MSMEs by convincing various stakeholders. The fear of the workforce about the loss of their job due to the adoption of LMPs can be alleviated with the proper utilisation of social benefits derived from LMPs. Apart from these, the practitioners can highlight the relevance of lean practices which would be a requirement for the success of MSMEs and also their survival in a global environment. The study will help to recognise the affinity of lean and sustainability to support the managerial community for convincing multiple layers of stakeholders in the investment and efforts incurred for the lean implementation.

Nowadays, the policy makers and agencies are continuously striving toward transferring of competency level of MSMEs so that the failure rate of MSMEs can be minimised (Urban and Naidoo, 2012). Upgrading competency and business sustainability of MSMEs is the primary concern in addressing economic development and combating unemployment. The findings of this study support the call for more targeted training and investment toward implementation of LMPs contributing to the endurance of MSMEs.

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2. Sajan, M.P and Shalij, P.R (2017), ”The Relationship between Lean Operations and Sustainability Among the Different Production Systems in Small and Medium Enterprises (SMES)”, *International Journal of Engineering Technology, Management and Applied Sciences*, Vol. 5, No. 7, pp. 239-243.

3. Sajan. M.P and Shalij, .P.R. "An empirical investigation of statistical divergence of the areas of linkage between lean and sustainability in Indian Manufacturing SMEs", *International Journal of Manufacturing Technology Management*, accepted for publication.

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APPENDIX I

QUESTIONNAIRE

SECTION A FIRMS BASIC INFORMATION

Please tick(✓) appropriate boxes related to your firm

1 Type of industry /sector

☐ Automotive/Machinery ☐ Metal/Mechanical ☐ Electrical & Electronics

☐ Food Based ☐ Leather Base ☐ Paper & products

☐ Plastic & Polymers ☐ Rubber ☐ Textiles & garments

☐ Chemical ☐ Wood ☐ Others (specify)

2 Nature of manufacturing process

☐ Job shop ☐ Batch ☐ Flow production

3 Age of the firm (in Years)

☐ 1- 4 ☐ 5-8 ☐ 9-15 ☐ 16-25 ☐ More than 25

4 Number of employees

☐ Less than 10 ☐ 10 – 50 ☐ 51 -100 ☐ 101 to150 ☐ 150-200

☐ 200-250 ☐ 250-300 ☐ 300-500 ☐ More than 500

5 The firm is managed by

☐ Owner ☐ Manager ☐ Entrepreneur ☐ Government

6 Business environments

☐ Competitive ☐ Monopoly ☐ Growth ☐ Decline

7 Products demand

☐ Level Demand ☐ Cyclic ☐ Trend ☐ Seasonal

8 Product / Category :

☐ Make to stock ☐ Make to order ☐ Assemble to stock ☐ Assemble to order

9 The firm is certified

☐ ISO 9000 ☐ ISO14000 ☐ ISO22000 ☐ NA

10 As per the investment, firm is

☐ Micro scale ☐ Small ☐ Medium ☐ Large

SECTION B LEAN AMANUFACTURING PRACTICES

11 On a scale 1-5 . Please indicate your level of agreement wit each statement related to your firm

	1:strongly Disagree 2: Disagree 3:Neither agree nor Disagree 4: Agree 5:Strongly Agree	**Strongly Disagree**	**Disagree**	**Neutral**	**Agree**	**Strongly Agree**
LMP 01	Our plant emphasize putting all tools and fixtures in their proper place	1	2	3	4	5
02	We use standardized and documented processes which are well instructed to our employees	1	2	3	4	5
03	We focus to reduce process set up time – the time required to prepare or refit equipment, workstations etc.	1	2	3	4	5
04	Workers carry out routine maintenance on all equipments (eg, Cleaning, lubrication or small repairs) following standard procedures	1	2	3	4	5
05	Many equipment problems have been solving through small group sessions	1	2	3	4	5
06	Our plant following either preventive/predictive maintenance	1	2	3	4	5
07	We use kanban pull system (or containers of signals) for production control	1	2	3	4	5
08	We can depend on time delivery of our suppliers	1	2	3	4	5
09	We have build close, long-term relationships with our suppliers	1	2	3	4	5
10	we have high levels of information transparency or information sharing with our suppliers	1	2	3	4	5
11	We form teams capable to do their daily work without formal leadership.	1	2	3	4	5
12	During problem solving sessions, we make an effort to get all team members' opinions and ideas before making a decision	1	2	3	4	5
13	We frequently are in close contact with our suppliers	1	2	3	4	5
14	We usually complete our daily schedule as planned.	1	2	3	4	5
15	We have a small amount of work-in-process inventory.	1	2	3	4	5
16	The layout of the shop floor facilitates low inventories and fast throughput	1	2	3	4	5

17	We emphasise the continuous improvement of product quality in all work processes.	1	2	3	4	5
18	We have an effective process for resolving customers' complaints	1	2	3	4	5
19	Customer needs and expectations are effectively disseminated and understood throughout the workforce	1	2	3	4	5

SECTION C SUSTAINABILITY PERFORMANCE

12 On a scale 1-5, rate the following performance indicators of your firm, compared to your primary competitors, during last 3 years

	1: Much Worse 2: Somewhat Worse 3:Stayed the same 4: Somewhat Better 5: Much Better	**Much Wo rse**	**Some what worse**	**Stayed the Same**	**Some what Better**	**Much Better**
SP 01	Low Operational cost	1	2	3	4	5
02	Growth in Market Value	1	2	3	4	5
03	Growth in Profit	1	2	3	4	5
04	Reduction in Environmental Business wastage (ie Non Value added activities)	1	2	3	4	5
05	Reduction in Emission /unit of Production	1	2	3	4	5
06	Reduction in Material Usage/ Output	1	2	3	4	5
07	Reduction in Energy/ Fuel usage	1	2	3	4	5
08	Safety and Health	1	2	3	4	5
09	Labour Relationship	1	2	3	4	5
10	Training and Education	1	2	3	4	5
11	Decrease in Rate of consumer complaints	1	2	3	4	5
12	Technology Improvement	1	2	3	4	5

SECTION D AREAS OF LINKAGE BETWEEN LEAN AND SUSTAINABILITY

13 In your opinion, what are the areas of linkage between lean practices and sustainability in your firm

	1:Strongly Disagree 2:Disagree , 3:Neither agree nor Disagree 4:Agree 5:Strongly Agree	**Strongly Disagree**	**Disagree**	**Neutral**	**Agree**	**Strongly Agree**
01	Waste Reduction	1	2	3	4	5
02	Environment Management	1	2	3	4	5
03	Supply chain Management	1	2	3	4	5
04	Worker Empowerment	1	2	3	4	5
05	Better Quality	1	2	3	4	5
06	Health And safety Improvement	1	2	3	4	5
07	Value Maximization	1	2	3	4	5
08	Energy Minimization	1	2	3	4	5
09	Resource Management	1	2	3	4	5
10	Optimum Design	1	2	3	4	5
11	Cost Reduction	1	2	3	4	5
12	Performance Improvement	1	2	3	4	5
13	Transparency	1	2	3	4	5
14	Continuous improvement	1	2	3	4	5
15	Community strategy	1	2	3	4	5
16	Governance	1	2	3	4	5

Any other Comments:

Thank you for taking your precious Time to fill the questionnaire

Firms name and address (optional)

Name of Respondent: Designation:

Mobile: Email: signature:

APPENDIX 2
INTRODUCTORY LETTER

Dear Sir/Madam,

This is to request you to kindly spare your valuable time to respond to a questionnaire for a research project on the topic "Lean Practices in MSMEs & their effect on Performances"

I assure that Responses given by you will be used only for academic purpose and not used for any other purpose. Data given by you will be strictly kept confidential and individual company analysis will not be done.

Thank you very much for your help and cooperation

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To whom so ever it may concern

Sub: Academic Research on the topic " Lean practices on MSMEs & their effect on performance"

Ref: 1) Letter dated 1/2/2016 from Dr.Shajili, PR, Associate Professor, Dept of Production Engineering, Govt. Engineering College, Thrissur

2) Letter dated 8/2/2016 from Sri. Sajan M.P, PR, Assistant Professor, Govt. Engineering College, Thrissur

I am writing this reference letter at the request of Dr.Shajili, PR, Associate Professor, Dept of Production Engineering, Govt. Engineering College, Thrissur and Sri.Sajan M.P, Assistant Professor, Govt. Engineering College, Thrissur. Sri. Sajan M.P is a research scholar under the guidance of Dr.Shajili, doing PhD on the " Lean practices on MSMEs & their effect on performance". The objective of this academic research is to study operational and sustainable performance of MSMEs by the implementation of lean practices along with green and social practices. As part of this research, it is necessary to get some relevant data about the above mentioned practices and manufauring technologies in various manufacturing industries in Kerala by means of questionnaire survey, direcly or by email.

Hence I recommend to kindly provide the data related to the above topic available with your esteemed organization for academic purpose to Sri.Sajan M.P, Assistant Professor, Govt. Engineering College, Thrissur.

Yours faithfully,

Director of Industries & Commerce