ISTANBUL TECHNICAL UNIVERSITY ★ GRADUATE SCHOOL OF SCIENCE ENGINEERING AND TECHNOLOGY

A STATISTICAL ANALYSIS OF LEAN PRACTICES, AND IMPACTS ON SMALL AND MEDİUM-SIZED ENTERPRISES (SMEs) IN PAKISTAN

M.Sc. THESIS

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Department of Industrial Engineering

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İSTANBUL TEKNİK ÜNİVERSİTESİ ★ FEN BİLİMLERİ ENSTİTÜSÜ

PAKİSTAN'DA KÜÇÜK VE ORTA ÖLÇEKLİ GİRİŞİMCİLER İÇİN YALIN UYGULAMALARİ VE ETKİLERİNİN ANALİZİ

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Zanjbeel Tabassum, a **M.Sc.** student of ITU **Graduate School Of Science Engineering And Technology** student ID 507121131, successfully defended the **thesis/dissertation** entitled "A Statistical Analysis of Lean Practices, and Impacts on Small And Medium-Sized Enterprises (SMEs) in Pakistan", which she prepared after fulfilling the requirements specified in the associated legislations, before the jury whose signatures are below.

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Date of Submission : April 2016
Date of Defense : May 10, 2016

To my parents and siblings,

FOREWORD

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May 2016

Zanjbeel TABASSUM
(Industrial Engineer)

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ABBREVIATIONS

SME	**:** Small Medium Enterprise
CSF	**:** Critical Success Factors
HRM	**:** Human Resource Management
WIP	**:** Work in Process
JIT	**:** Just-in-Time
LSS	**:** Lean Six Sigma
TPM	**:** Total Productive Maintenance

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A STATISTICAL ANALYSIS OF LEAN PRACTICES, AND IMPACTS ON SMALL AND MEDIUM-SIZED ENTERPRISES (SMEs) IN PAKISTAN

SUMMARY

The main purpose of any economic investment is to get profit at the end. Investors and business holders invest in business or shares for wealth maximization. As the investment in large companies bears complexities, which influences investors to invest in small or medium enterprises which converts into medium or large companies at the later stage with profitability. The increasing competition because of the globalization is forcing SMEs to seek new methodologies and process for production and management. One of the methodologies which is gaining importance among manufacturing and service industries is Lean thinking.

As the world is gaining much advancement in the lean manufacturing techniques. Pakistani SMEs are still far behind in this race. The purpose of this research is to analyze the lean implementation status in Pakistani SMEs. To get the insights of implemented lean practices, its benefits , barriers and critical success factors of lean in Pakistan SMEs, A survey methodology was used to collect the data from Small Medium Enterprise in Pakistan. This study will provide a base for Pakistani SMEs to analyze their position as compared to the other SMEs and help them to improve their performance in terms of lean practices. Also it will help future researchers working in Lean implementation to prepare a road map to eradicate the hurdles in Lean implementation in Pakistani SMEs.

This research summarizes that Lean implementation needs to start from adopting basic lean tools. And while implementing lean in the companies there will be lots of barriers faced by companies which will show a negative influence on the lean implementation but those barriers can be overcome by working on some critical success factors which will have positive affect on the implementation of lean. The successful lean implementation will bring benefits to the SMEs and will affect different aspects of an organizations performance, in terms of Operations performance and business performance.

PAKİSTAN'DA KÜÇÜK VE ORTA ÖLÇEKLİ GİRİŞİMCİLER İÇİN YALIN UYGULAMALARİ VE ETKİLERİNİN ANALİZİ

ÖZET

1950 yıllarında Japonya'da Toyota Motor şirketi tarafından geliştirilen yalın üretim sistemi, en az kaynakla, en kısa zamanda, en ucuz ve hatasız üretimi müşteri talebine bire bir uyacak şekilde en az maliyetle gerçekleştirebilme arayışının sonucu olarak doğmuş bir sistemdir. Bu sistem 1970'li yıllarda yaşanan ekonomik durgunluk ve petrol krizi dönemine kadar dünya otomotiv sanayinin gerçek anlamda dikkatini çekmemiştir. Ancak zaman içerisinde bu teknikler yalın felsefeyi doğurmuş, bu felsefe de, otomotiv sektöründen dışa açılarak elektronik ve beyaz eşya sanayisine, tekstil sanayisinden, plastik ve metal işlemeye, tarım ve hayvancılık sektöründen, hizmet sektörüne üretimin olduğu her alanda kabul görmüştür.

Günümüzde müşteri kavramı yeni bir boyut kazanmıştır. Müşteriler artık daha kaliteli ürünleri daha ucuza temin edebilmenin yanı sıra, kullandıkları ürünlerin kendilerine özgü olmasını da istemektedirler. Bu gelişmeler işletmeleri, ürünleri müşteri zevk ve tercihlerine uygun olarak etkin ve verimli bir şekilde üretebilecek yeni üretim stratejilerini ve teknolojilerini kullanmaya zorlamaktadır. Günümüz üretim sistemlerinde etkin ve verimli bir şekilde çalışan yeni nesil üretim stratejilerinin ön plana çıkmasının nedeni, bu üretim sistemlerinin müşteri zevk ve tercihlerini çok kısa sürede karşılayabilmeleridir. Bu üretim yöntemlerinden en önemlisi ve en başarılısının Yalın Üretim (Lean Production) olduğu kabul edilmektedir.

Ekonomik yatırımda ana hedef kar etmektir. Yatırımcı ve hissedarlar karlarını artırmak amacıyla yatırım yaparlar. Büyük ölçekli şirketlerin karmaşık yapıları, küçük veya orta ölçekli girişimcilerin yatırımlarını etkileyerek, sonraki aşamalarda büyük ölçekli şirketlerde kar edilebilir yatırıma dönüşür. Küreselleşme ve rekabet KOBI' lerin yeni üretim, yönetim proses metodoloji arayışlarına zorlamaktadır. Hizmet sektöründe ve üretimde artış metodolojisi yalın düşüncedir. Günümüz rekabet ortamında eğilim, müşteri talebine hızlı cevap vermek ve yüksek kaliteli, düşük fiyatlı ürünler sunmaktır. Dünya çapında firma olmak için israfi ortadan kaldırmak ve etkin bir iş akışı gerçekleştirmek tüm yöneticilerin hedefi olmalıdır. Bu tam olarak yalın üretim felsefesinin ulaşmaya çalıştığı hedeftir. Ülkemizin ve dünyanın içinde bulunduğu ekonomik koşular ve acımasız rekabet ortamı, verimlilik artışını zorunlu kılmaktadır. Verimlilik artışının sağlanması yeni makineler satın alma veya işçi alımı gibi maliyet arttıran yöntemlerle değil, mevcut üretim ve yönetim sistemine birtakım verimlilik yöntemlerinin uygulanması ile mümkündür.

Zaman içerisinde Yalın üretim ve türevi olan ama temelde aynı hedefleri barındıran yeni üretim teknikleri olan Kaizen , Altı Sigma , Yalın Altı Sigma ; yöntemleri, felsefeleri ve uygulamaları ile kendilerini ortaya koymuştur. Bu tekniklerin hepsi odak noktası olarak müşteriyi konumlandırarak sürdürülebilir ve geliştirilebilir kalite ihtiyacını hedeflemiştir. Bunu yaparken sınırlayıcı en temel dinamik işletmenin genel yaşam hedefi olan kãrı artırma çabası olmuştur.

Dünyadaki Yalın üretim tekniklerindeki ilerleme olmuştur. Pakistan'da KOBİ' ler hala bu yarışın çok uzağındadır. Bu araştırmanın amacı Pakistan'daki KOBİ' lerin yalın uygulamaların analizidir. Pakistan daki KOBİ' lerin yalın uygulamaları önemli başarı faktörlerine faydaları olacaktır.

Pakistandaki KOBİ'lerde yalın uygulanmasının analizi için bir anket metodolojisi kullanılmıştır. 124 şirket ankete katıldı. İmalat ve hizmet, şirketlerin hem tip, otomobil, metal eşya, kağıt ve ambalaj, kimyasallar, tekstil, yiyecek ve içecekler, elektrik bileşenleri ilaç, dağılımları, depolama ve tüketici hizmetlerini içeren ankete katıldı. En yaygın uygulanan araçlar Kalite belgesi (örneğin ISO), İşyeri organizasyonu (5S), Çalışma standardizasyon ve Süreç haritalama vardır. KOBİ'lerde yalın uygulanan araçların daha iyi anlamak için, bir küme analizi yaptik, son derece Yalın şirketleri (küme 1), Biraz Yalın Şirketleri (Küme-2) tüm Yalın Değil (Küme-3) olarak adlandırılan üç farklı küme içine davalı şirketlerin bölünmüştür.

İşyeri organizasyonu, iş standardizasyon, sürekli iyileştirme programı, süreç haritalama ve kaizen olayları son derece yalın şirketlerin en sık uygulanan yalın araçlardır. Bu sonuçlar yalın şirketler sistemlerin genel etkinliği ve verimliliği odaklanmak olduğunu göstermektedir. Öte yandan, biraz yalın şirketler için, bu kategoride en yaygın yüksek uygulanan araçlar İşyeri organizasyonu (5S) Kalite belgesi (örneğin ISO), Süreç haritalama ve İş standardizasyon vardır. tüm Yalın Değil şirketler için, En yaygın yüksek uygulanan araçlar Kalite belgesi (örneğin ISO), Just-in-time (JIT), tek parça akış, Çalışma standardizasyon, İşyeri organizasyon (5S) vardır. Öte yandan en az uygulanan yalın araçlar çekme / Kanban ve Altı Sigma vardır, Bu çünkü sistemin detaylı bir çalışma gerekir araçlardır ve bu araçlardan yararlanmak için sürekli çaba ve finansal istikrarı gerektirir.

Yalın faydaları listesi de araştırmaya dahil edildi. Atıkların azaltılması, artan kar ve verimlilik, geliştirilmiş verimlilik üst faydaları davalı şirketler tarafından belirtilmiştir. Yalın uygulamaların atıkların azaltılması, kar artışı, üretim iyileştirme ve müşteri memnuniyeti ile pozitif bir ilişki var demektir. Davalı şirketlerin aynı zamanda yalın uygulanması için karşı karşıya engelleri vurgulamak için istendi. KOBİ'lerde yalın uygulanan araçların daha iyi anlamak için, aynı küme analizi yaptik, son derece Yalın şirketleri (küme 1), Biraz Yalın Şirketleri (Küme-2) tüm Yalın Değil (Küme-3) olarak adlandırılan üç farklı küme içine davalı şirketlerin bölünmüştür. Her üç küme arasında, değişime direnç, en yüksek puan engel oldu. Diğer önemli engel arasında eğitim ve öğretim vardır.

Bir faktör analizi yalın uygulama Kritik başarı faktörlerinin daha iyi anlayabilmek için yapıldı. 13 faktör üç ana bileşenden indirgendi. Bileşen-1 aşağıdaki faktörlerden oluşur: Tedarikçi yönetimi, insan kaynakları yönetimi, sürekli değerlendirme ölçümü ve çalışanın Güçlendirme. Eğitim ve öğretim, Örgüt kültürü, Çalışan katılımı ve Yönetim taahhüdü ve liderliği Bileşen-2 tarafından sunulmaktadır. Kalite yönetimi, sürekli iyileştirme ve Uygulanabilir yalın uygulamalar Bileşen-3 parçalarıdır. Etkili iletişim ve müşteri yönetimi Bileşeni-4 altında gelir. Bileşenler şirket türlerine göre karşılaştırılmıştır, yani Mikro Şirketler (<10), Küçük Şirketler (10-49), Orta Şirketler (50-249). Bileşeni-1 Küçük şirketler için en yüksek puana sahiptir. Bileşen 2 ve bileşen 3 orta imalat ve bileşen-4 Mikro Şirketler için en yüksek puana sahiptir.

Araştırmada Pakistan da küçük ve orta girişimcilerden toplanan veri metodolojisi kullanıldı. Araştırma Pakistan KOBİ' lerine kendi pozisyonlarını analiz ederek, diğer KOBİ' ler ile kıyaslama ve kendi performanslarını yalın uygulamalarla geliştirmelerini sağlayacaktır. Pakistan daki KOBİ' lerin yalın uygulamalar ile sorunların çözümünde yol haritası hazırlanarak, sonraki araştırmalara ışık tutacaktır.

Yalın üretim uygulanması zor bir yöntem değildir. Ancak uygulanan firmada tüm çalışanların yalın üretim felsefesine inanması ve sahiplenmesi gerekir ve yoğun disiplin gerektirir. Stoklu çalışılmadığı için çok hassas bir üretim planlama ve malzeme tedariğini gerektirir. Aksi taktirde işletmenin her hangi bir istasyonunda meydana gelecek akış aksaklığı, tüm sistemi etkileyecek ve akışı bozacaktır. Üretimim her noktası aynı ritimle ilerlemeli ve asla bu ritim bozulmamalıdır. Yalın üretim sisteminde israf kabul edilen her türlü bekleme, taşıma, yürüme, arıza, uygunsuz proses yok edilmeli ve tüm çalışanların bu felsefeye katılımı gerçekleştirilmelidir.

Bu çalışmada da gösterildiği gibi bir işletmede yalın üretim teknikleriyle beraber sürekli iyileşme felsefesinin tüm çalışanlar tarafından benimsenmesi ve uygulanması ile firma müşterilere çok daha hızlı, düşük maliyetli ve kaliteli ürünler sunabilecektir. İşletmelerin müşteriler tarafından tercih edilebilmelerinin ve ayakta kalabilmelerinin tek yolu rekabetçi olabilmeleri, yani en düşük maliyete en kaliteli ürünleri sunabilmeleridir. Günümüz üretim sistemlerinde bunu başarabilmenin en güçlü anahtarı yalın üretim sistemidir.

1. INTRODUCTION

1.1 Purpose of Thesis

The increasing competition because of the globalization is forcing companies to seek new methodologies and process for production and management. One of the methodologies which are gaining importance among manufacturing and service industries is Lean thinking, it is an approach which focuses on eliminating non-value-added activities from processes by applying a robust set of performance change tools, and emphasizing excellence in operations to deliver superior customer services (Shah and Ward, 2003). The companies which have adopted lean practices are having superior operational and financial performance over the companies which have not adopted yet (Fullerton and Wempe, 2009; Shah and Ward, 2003). The competition in global market is forcing Small medium enterprises to focus on new production methodologies to survive in the market. The literature has highlighted a number of research gaps related to the Lean practices and impacts on Small and Medium size enterprises. Though a number of studies have been performed on lean practices in large organizations but there is a lack of research work exists in literature related to Lean practices in SMEs and especially in Pakistan. There is a need to investigate the issues related to awareness, implementation and perceived benefits of lean practices in organizations in the context of small and medium enterprises which is the main purpose of this thesis.

1.2 Research Objectives

Undertaking the research gaps in this area a number of research objectives have been taken into consideration which are outlined below:

- Do small medium enterprises in Pakistan aware of Lean?
- To what extent Lean Management practiced in Small medium enterprises in Pakistan?
- Is the level of lean awareness varies with company size and type?

- Have small medium enterprises in Pakistan implemented lean practices?
- What is the current level of lean practices in SMEs?
- Which lean tools have been implemented mostly?
- Does the degree of lean implementation vary with Contextual variables of the company, company size and industry segment?
- What is the relationship between each of fundamental lean practices?
- Is there any association with the level of lean implementation and the period of time since lean practices have been implemented?
- What are the critical success factors in lean manufacturing in SMEs
- What are the barriers with the implementation of lean practices in SMEs
- What are the benefits/impacts of implementing lean in SMEs

1.3 Research Overall Methodology

Research overall methodology used in the research work of this thesis (Table-1.1) is summarized as follows:

- Conducting a detailed literature review on evolution of lean, Lean concepts, Lean principles, Benefits, Barrier, Critical success factors and lean implementation in SMEs.
- Developing research questions and developing questionnaire survey based on the research gaps from the literature review for Small Medium Enterprise in Pakistan.
- Collecting data using survey method from Pakistani Small and Medium size enterprises.
- The results of the survey were analyzed using SPSS software to get the detailed picture of lean implementation in Small Medium Enterprises in Pakistan
- Applying a number of analysis using SPSS such as Descriptive Measures, Correlation, Factor Analysis and Comparison of Means
- Making necessary inferences according to the analysis of the data set.

Table 1.1: Research Methodology.

Process	Approach
Formulation and Conceptualization	Literature Review
	Research Gap Analysis
	Research Questions
Data Collection	Online Questionnaire Survey
	Collecting data from Pakistani SMEs
Data Analysis	SPSS Software
	Descriptive Measures
	Correlation
	Factor Analysis
	Comparison of Means
Operationalized the Research	Thesis defense
	Improvement, if necessary
• **Publish the Research**	Publishing the findings

1.4 Thesis Format

There are five chapters that include Chapter 1 Introduction which is made up of purpose of thesis, research objectives and research methodology, Chapter 2 will support my work through literature review, Chapter 3 will discussed the methodology used for research purpose, Chapter 4 Data Collection and Results, In Chapter 4 analysis of the collected data will be explained through interpretations of results. Chapter 5 will conclude the summary of statistical analysis techniques, discussion of major findings, and implication of results, limitation and recommendations.

2. THEORETICAL BACKGROUND

2.1 Evolution of Lean

Henry Ford was the first person to develop and manufacture an automobile which a middle class American family could afford by integrating an entire production system (Shah and Ward, 2003). The concept of shop practices using general-purpose machines grouped by process was changed by Henry Ford who tried his best to create the flow production by lining up the production steps in process order wherever possible. He explained his philosophies of production in his books "Today and Tomorrow" explaining the Ford production system (Shah and Ward 2003). Ford Production System was lacking in terms of variety of products. The roots of lean reach back to the shop-floors of the Toyota Motor Corporation Japan during 1970s when the greatest pressure for quality and speed were on manufacturing. Taiichi Ohno, a production engineer at Toyota Motor Corporation Japan studied the Ford Production System and concluded that by making some simple variations in FPS, it is possible to get a variety of products using continuous process flow. Ohno's book "Toyota Production System" explains the principles and techniques used at Toyota Motor Corporation, in which Just-in-Time is the key component of TPS (Shah and Ward, 2003). In order to reduce costs and inventory levels while increasing profits, Toyota asserted that the customary thinking that Cost + Profit = Sales Price was incorrect. Instead, they believed that Profit = Sales Price – Cost. Thus Toyota began a manufacturing system that focused on the management of costs. Eventually costs were interpreted as waste, and all varieties of wastes were targeted for elimination. It is due to this advance in innovation that Toyota is referred to as the birthplace of lean (Bicheno and Holweg 2009). Lean arose as a method for optimizing automotive manufacturing from the study of the Toyota production system (Womack et al, 1990). The term "lean" was first used by Krafcik (1988) for a production system that uses fewer resources compared to mass production. Womack and Jones (1996) extended the lean concept beyond just automotive

manufacturing and beyond manufacturing itself in their later book "Lean thinking". The main purpose of lean thinking was the elimination of any kind of waste. Waste is everything that increases cost without adding value for the customer (Womack and Jones, 1996). Differences between Lean and Mass production highlighted by Womack et al, (1990) are summarized in Table 2.1.

Table 2.1: Difference between Mass and Lean Production.

	Mass Production	**Lean Production**
Basis	Henry Ford	Toyota
Workers	Narrowly skilled dependent workers	Multi-skilled workers throughout the organization
Lead Time	Long	Short
Flexibility	Low	High
Product	Standardized	Customized
Machines	Expensive, specific-purpose machines	Manual and automated systems for large variety and high volume of products
Organizational philosophy	Hierarchical management take responsibility	Level of empowerment and responsibilities are divided through out the organization
Production philosophy	Focus on cost-high production, less quality	Focus on Quality with less cost
Scheduling	Forecast-Push system	Customer order-Pull
layout	Functional	Product Flow

Waste elimination, Continuous improvement, zero defects, just in time delivery, Pull system, multifunctional teams, decentralization, process integrations, vertical flow of information are the nine principles to access lean performance in an organization (Karlsson and Ahlstrom, 1996). To get the full benefits of lean, the organization should implement all the activities based on these principles. The terms Lean manufacturing, Just in time and Toyota productions systems are used interchangeably due to the same principles attached to these terms (Heizer and Render, 2011; Taj, 2005). Research has shown that Lean manufacturing has a great influence on the success of Japanese and US economies in the last few decades. The firms' high performance depends on the successful implementation of lean systems (Krafcik, 1988). The concept of LM is spreading across the globe because of its advantages related to cost, quality, productivity and flexibility

(Stone, 2012). Various research studies have highlighted the benefits the companies have achieved with waste reduction applying lean practices.

2.2 Lean Definition

Ohno (1988) defines the purpose of Toyota production system in his book titled "The Toyota Production System, Beyond Large-Scale Production" as "The basis of the Toyota Production system is the absolute elimination of Waste". In support of Ohno (1988)'s work, Krafick (1988) was the first person who used the term "Lean". He defines the main purpose of lean is to reduce the cost by identifying and elimination non-value added activities or wastes which do not add any value for the end customer (Krafcik, 1988). Further argument on the subject of lean manufacturing was discussed in detail in Womack et al, (1990)'s book titled as "Machine that changed the world". Womack et al, (1990) called it lean manufacturing which can produce products by using fewer resources, inventory, material, space and people and it will affect everything in the industry by combining the benefits of craft and mass production. Wilson (2010) gives a definition of Lean in his book "How to implement Lean Manufacturing" as:

> *"It is a comprehensive set of techniques that, when combined and matured, will allow you to reduce and then eliminate the seven wastes. This system not only will make your company Leaner, but subsequently more flexible and more responsive by reducing waste"*

2.3 Lean Principles

2.3.1 Womack and Jones's 5 principles

In the book "Lean Thinking" Womack and Jones (1996) have identified the concept of Lean thinking which a remedy for Muda. Lean thinking is more concerned about creating value and to transfer that value to the customer in the most efficient way using minimum resources. There are 5 major lean principles defined by Womack and Jones (1996) which are listed here:

1) **Specify Value:** The starting point for Lean is to understand that only a small portion of all the activities performed by the organization will add value to the final product. The main target should be to identify and define the value

for the product according to the customer perspective and then all the non-value added activities should be identified for the removal.

2) **Identify the value stream:** Value stream is all the activities that the organization will perform to deliver the final product or service to the end customer. This represents all the activities which will deliver value to the customer. So once the value for the customer will be defined the next process will be identifying the value stream to deliver that value to the end customer.
3) **Create Flow:** once the value stream map will be identified then we will come across all the non-value added activities which are waste activities. The next step would be removing all those non-value added activities so that we get a smooth flow to transfer the value the end customer without any disturbance or disruption.
4) **Pull system:** This principle defines that the organizations should be responsive to the customer pull. They should be responsive to the customer demand and they should try to meet the customer demand in terms of what they want and when they want.
5) **Strive for Perfection:** After defining the value stream and creating a continuous flow and pull system, all the activities will be joined together and more and more non-value added activities and wastes will become visible and by eliminating or reducing those wastes the organizations can pursue perfection in which each and every activity will be adding value for the end customer.

2.3.2 Toyota's 14 Lean principles

In his book "The Toyota Way" Liker (2004) has defined 14 Toyota Principles also known as Lean principles. These 14 principles are summarized here:

1) Base your management decisions on a long-term philosophy, even at the expense of short-term financial goals: This is the most difficult principle to achieve and it is the base of the other principles. Because the organizations must have to focus on the long term goals instead short term pay back periods if they want to survive for the long run. And to achieve this goal you must have to satisfy your customer by doing the right things for the customer. The starting point for an organization is to focus to create value for the customer, society and economy. While doing so, each and every member of the organization must take

individual responsibility and try to create the environment of mutual interest and understating to achieve long term goals.

2) Create a continuous process flow to bring problems to the surface: Create a process flow with minimal waste of time. Reduce the lead time as much as possible by creating flow to move material and information as fast as possible. The advantage of continuous flow is that it features stability, continuity, balance and it does not waste time. It is not easy to create continuous flow in the process because each process had its inherent waste times and when you start creating continuous flow these problems come to the surface and to achieve a continuous flow one must has to solve those problems first. By making the continuous flow evident throughout the organization will ensure the true continuous improvement and helps in people development.

3) Use 'Pull' systems to avoid overproduction: This principle focuses on the material replenishment which is the basis of Just-in-time process. The focus should be on to meet the down line customer requirements at the right time and in the right amount using Pull system. The basic principle of Pull system is that each process keeps a small amount of inventory for the next system and only replenishes that inventory when it has been taken by the next process. It helps in reducing over production and over ordering. Replenish the inventory based in the daily consumption rate to meet the requirements in time.

4) Level out the workload (work like the tortoise, not the hare): eliminating or reducing waste in very important in lean but it is just one part of the lean production another important feature of lean is to level out the work and reduce the over burdening of workers. The processes should be designed in such a way that it gives equal workload to all the workers or the work stations. The unevenness in the process should be reduces.

5) Build a culture of stopping to fix problems, to get quality right the first time: To achieve quality right at the first time is one of the basic features of lean production. The organizations should ensure the quality in the system by using appropriate quality assurance tools and techniques. There should be built in quality systems in the equipment which will detect the problems right at the time when it gets created. One of those is Jidoka (Machine with Human intelligence) to ensure quality right at the first time.

6) Standardized tasks and processes are the foundation for continuous improvement and employee empowerment: standardization is the basis for continuous improvement and quality. In a lean environment each and every process should be standardized to get the best output with the best quality. Because each worker can show its way of performing a task but the standardized methods should be introduced throughout the organization so that when a person leaves then it will be easy to transfer his job to the next new person joining.

7) Use visual controls so no problems are hidden: use visual signs to help the workers know that whether they are doing their tasks in standardized way or not. Some of the visual controls can be in the form of charts, graphs, gauges, signs, colors, shapes, numbers etc. The labels on the cartons and the floor lines are also good examples for visual detectors. Reduce the paper work as much as possible. Try to use one piece of paper for the reports even if the reports are of high importance. Visual control systems help in creating value added flow.

8) Use only reliable, thoroughly-tested technology that serves your people and process: Technology must support your people, processes and values. Technology should support people and not to replace them. Because people do the work and technology moves the information Sometime the organizations think that adopting new technologies will decrease all the problems which are not true in all cases. Organizations should adopt the technologies which are widely tested, proved and accepted. Before adopting any technology proper tests should be done to ensure that the new technology will cope up with the existing processes and technologies**.**

9) Grow leaders who thoroughly understand the work, live the philosophy, and teach it to others: Organizations should focus on growing the leaders rather than purchasing them from outside. Organizations work best with its leaders. Leaders should not be the people who just focus on accomplishing tasks rather they should develop the ways of performing tasks and they should be the role models for the other people working under them. Leaders should focus the organization philosophy and their actions should be directed towards achieving that philosophy.

10) Develop exceptional people and teams who follow your company's philosophy: one of the important lean principles is to focus on the Team work.

The organizations should develop the ways in which employees individual developments as well team work establishes. Cross functional teams should be built to achieve mutual corporation and understanding. The people should work as a team to achieve company's philosophies. Their major concern should be achieving the goals of the organization using organizational tools.

11) Respect your extended network of partners and suppliers by challenging them and helping them improve: Organization cannot work independently. In one way or another they depend on some external partners it can be in terms of suppliers, information technology providers, raw material providers or distributors etc. Organizations should give respect to their external partners and consider them as a part of their organization. Grow together to mutual benefits in the long term. Give them challenging tasks and help them grow.

12) Go and see for yourself to thoroughly understand the situation: whenever a problem occurs then the problem should be observed by yourself. Instead of believing on what others say or what computer screen is describing the best way to understand the problem is to go the source of the problem and investigates it by yourself. Even the managers and the heads of the departments should also follow the same rule. It will ensure that you have understood the problem on your own and you will create the best solution for that.

13) Make decisions slowly by consensus, thoroughly considering all options: The decisions should not be based on just one opinion. Before taking any decision all the alternatives should be considered. All the opinions should be gathered and then the best should decision should be made. *Nemawashi* is the process which ensures that the problems should be discussed with all the people who have got affected with that problem. Their opinions should be well considered before taking any decision. Though it is a time consuming process but it will avoid the losses which you can face later with the wrong decision.

14) Become a learning organization through relentless reflection and continuous improvement: After establishing a stable process the next focus should be on the continuous improvement to decrease the wastes as much as possible. The processes should be designed in such a way that they require almost no inventory to avoid all kinds of wastes. This principle also focuses on what you have previously done and what were your results from your previous

project. You should understand your mistakes from the previous projects and you try to avoid those mistakes in the next projects.

2.4 Types of Wastes

Muda (waste), Muri (Overburden) and Mura (unevenness) are the Japanese words used by Toyota Production system during their journey to lean. These three concepts help to understand lean more completely. "Mura and Muri lead to Muda" (Bicheno and Holweg, 2009). Liker (2004) has mentioned seven major types of wastes in his book The Toyota Way which were identified by Taiichi Ohno and the eight waste identified by Liker, listed here:

1) **Over Production:** Means producing more items than actually needed which will result costs in the form of space, over staffing and inventory.
2) **Waiting:** Any kind of time waste which causes disrupting in the continuous flow. It can be in the form of waiting for equipment, supply, tools or information for the next task etc.
3) **Unnecessary Transportation:** Unnecessary movement of materials, tools or products or moving work-in-processes for long distances
4) **Over Processing:** processing beyond the standards required by the customer. Doing unneeded steps to make the parts and doing unneeded processing because of inefficient tools.
5) **Excess Inventory:** storing raw materials, work-in-process or finished goods for long time which is not creating any value for that duration, causes longer lead time, storage cost and deterioration costs.
6) **Unnecessary Movements:** unnecessary movements of people, parts and machines within a process. Unnecessary movement from ergonomics point of view is also a waste.
7) **Defects:** The extra efforts needed to repair or rework the defective products is a kind of waste, it causes extra costs in terms of delay, warranty or extra work force and customer does not pay for these kinds of defects.
8) **Unused Employee Creativity:** This is an additional type of waste which is caused by underutilizing people creativity, idea and competence. Organizations face this type of waste when they don't pay attention to their employees' abilities and don't listen to their voices.

Melton (2005) has further outlined the details and description of seven wastes and their examples in manufacturing industry listed in table 2.2.

Table 2.2: The seven types of Wastes (Source: Melton, 2005).

Type of waste	Description	Within the process industry	Example symptom
Over production	✓ Product made for no specific customer ✓ Development of a product, a process or a manufacturing facility for no additional value	✓ Large campaign—large batch and continuous large-scale manufacturing processes ✓ Development of alternative process routes which are not used or the development of processes which do not support the bottleneck ✓ Redesign of parts of the manufacturing facility which are 'standard', e.g., reactors	✓ The extent of warehouse space needed and used ✓ Development and production organization imbalance ✓ An ever changing process (tweaked) ✓ Large engineering costs/time associated with facility modifications
2. Waiting	✓ As people, equipment or product waits to be processed it is not adding any value to the customer	✓ Storage tanks acting as product buffers in the manufacturing process—waiting to be processed by the next step ✓ Intermediate product which cannot leave site until lab tests and paperwork are complete	✓ The large amount of 'work in progress' held up in the manufacturing process—often seen on the balance sheet and as 'piles of inventory' around the site
3. Transport	✓ Moving the product to several locations ✓ Whilst the product is in motion it is not being processed and therefore not adding value to the customer	✓ Raw materials are made in several locations and transported to one site where a bulk intermediate is made. This is then transported to another site for final product processing ✓ Packaging for customer use may be at a separate site	✓ Movement of pallets of intermediate product around a site or between sites ✓ Large warehousing and continual movement of intermediate material on and off site rather than final product
4. Inventory	✓ Storage of products, intermediates, raw materials, and so on, all costs money	✓ Economically large batches of raw material are purchased for large campaigns and sit in the warehouse for extended periods ✓ Queued batches of intermediate material may require specific warehousing or segregation especially if the lab analysis is yet to be completed or confirmed	✓ Large buffer stocks within a manufacturing facility and also large warehousing on the site; financially seen as a huge use of working capital
5. Over processing	✓ When a particular process step does not add value to the product	✓ A cautious approach to the design of unit operations can extend processing times and can include steps, such as hold or testing, which add no value ✓ The duplication of any steps related to the supply chain process, e.g., sampling, checking	✓ The reaction stage is typically complete within minutes yet we continue to process for hours or days ✓ We have in process controls which never show a failure ✓ The delay of documents to accompany finished product
6. Motion	✓ The excessive movement of the people who operate the manufacturing facility is wasteful. Whilst they are in motion they cannot support the processing of the product ✓ Excessive movement of data, decisions and information	✓ People transporting samples or documentation ✓ People required to move work in progress to and from the warehouse ✓ People required to meet with other people to confirm key decisions in the supply chain process ✓ People entering key data into MRP systems	✓ Large teams of operators moving to and from the manufacturing unit but less activity actually within the unit ✓ Data entry being seen as a problem within MRP systems
7. Defects	✓ Errors during the process—either requiring re-work or additional work	✓ Material out of specification; batch documentation incomplete ✓ Data and data entry errors ✓ General miscommunication	✓ Missed or late orders ✓ Excessive overtime ✓ Increased operating costs

2.5 Lean Practices

There are a number of lean practices explained by researchers and are being practiced by industries. Some of the lean practices which are mentioned by researchers in the literature are listed in the table 2.3. The most common lean practices highlighted by researchers are Kanban, Work standardization, Continuous improvements, Just-in-time, Small lost size, quick change over and total quality management.

Table 2.3: Lean practices in literature

Lean Practices	Rose et al, (2011)	Real et al, (2007)	Bonavia and Marin, (2006)	Yauch and Steudel, (2002)	KARIM et al, (2011)	Womack et al, (1990)	Liker (2004)	Bicheno (2004)	Dennis (2002)	Feld (2001)	Ohno (1988)	Monden (1983)	Chan et al. (1990)	Flynn et al, (1999)	Sakakibara et al. (1997)	Koufteros et al, (1998)	White et al, (1999)	Lee et al. (1984)
Kaizen events			X			X	X	X	X	X	X	X	X	X	X	X	X	
Quality certification (eg. ISO)	X	X	X	X	X		X											
Work standardization	X	X	X	X			X	X	X	X	X	X	X	X	X	X	X	X
Visual management	X		X	X			X	X	X	X	X	X	X	X	X	X	X	X
Value stream mapping (VSM)						X	X	X	X				X	X	X	X		
Error proofing (Poka yoke)	X	X	X		X		X							X		X	X	
Cellular manufacturing	X			X				X		X		X	X	X	X	X	X	
Total productive maintenance (TPM)	X		X		X			X	X				X	X	X	X		X
Continuous improvement program	X				X								X	X	X	X	X	
One piece flow	X	X			X		X	X		X	X	X	X	X	X		X	
Workplace organization (5S)	X	X		X	X	X	X	X	X	X	X	X	X	X	X	X	X	
Energy management	X			X		X				X				X		X		
Quick changeover techniques	X	X	X		X	X	X	X	X	X	X	X	X	X	X	X	X	X
Pull system/kanban	X			X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
PDCA problem-solving													X	X	X	X	X	
Process mapping				X									X	X	X	X		
Benchmarking	X		X				X		X			X		X	X			
Six Sigma			X		X	X	X	X	X	X		X	X	X	X	X		
Environmental management	X		X			X			X		X				X	X	X	
JIT/continuous flow production					X	X	X		X	X	X	X	X	X	X	X	X	X
Lot size reductions	X	X			X		X	X		X	X	X	X	X	X		X	
Total quality management	X		X		X								X	X	X	X	X	
Preventive maintenance	X				X								X	X	X	X		X
Cross-functional work force	X	X		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Self-directed work teams	X	X		X	X	X	X	X	X	X	X	X	X	X	X	X		
Cycle time reductions	X	X	X		X	X	X	X	X	X	X	X	X	X	X		X	
Quality Circles	X	X	X		X				X		X				X		X	
Uniform Workload	X	X	X	X			X	X	X	X	X	X	X	X	X	X	X	X

Some of the lean practices are described here in detail:

- **Just-in-Time (JIT):** Meeting the specific customer demand in the right amount at shortest lead time
- **Jidoka (Best-in-Quality):** Designing the equipment to partially automate it which will automatically stop when it will detect a defect. It will give the opportunity to the workers to monitor multiple stations at the same time and will improve the quality as well.
- **Kaizen (Continuous Improvement**): Making small incremental improvements on a daily basis to remove wastes that is adding costs to the production without creating any value
- **PDCA:** A methodology which is used to implement the improvements: Plan (establish plan and expected results), Do (implement plan), Check (verification of the expected results), Act (review and access).
- **Kanban:** Use of signal cards to control the flow of goods within and outside the factory based on automatic replenishment to maintain a specific level of inventory. It will reduce the over production and extra inventory costs incurred.
- **Muda:** Anything in the manufacturing process that does not add value according to the customer perspective is called Muda and the primary focus of Lean manufacturing is to eliminate Muda.
- **5S (Sort, Stabilize, Shine, Standardize, and Sustain):** These are the series of tasks which are used to eliminate wastes and optimize productivity by maintaining the workplace in order and making the workplace efficient for use.
- **Poka Yoke (Error Proofing):** Design the process in such a way that it detects errors and prevents it on the spot where it is first created to get zero defects overall.
- **Root Cause Analysis:** A problem solving methodology which identifies the root of the problem to solve that problem from the root instead of getting immediate solution. It helps in ensuring that the problem is truly eliminated from the system.
- **Takt Time:** it gives the pace of the production by calculating planned production time divided by total customer demand.

- **Value Stream mapping:** it is a graphical tool which maps out the flow of the production in terms of current and future state map and highlights the areas for improvements.

Most of the studies strongly propose to implement comprehensive lean practices in the organizations in order to get fruitful the greater benefits of lean (Bhasin and Burcher, 2006).The benefits and the effect of continuous improvement will be less if the organizations adopt only a few of lean practices (Spann et al. 1999).

The true benefit of lean to strength the overall organizational system will be achieved if a number of lean practices will be implemented (Meier & Forrester 2002).

Practitioners have found that large organizations do not face any difficulties in implementing lean practices and are most likely to implement most of the lean practices as compared to small-medium organization (White et al, 1999; Shah and Ward, 2003).

Researchers have concluded that SMEs are incapable to adopt all the lean practices at once. Due to financial constraints, SMEs should implement feasible lean practices only, instead of implementing all tools at once (Lee, 1997).

The idea of Lee (1997) was also supported by White et al, (1999), which have highlighted a few lean practices, set up time reduction, Pull/Knaban System, Total Quality Management and productive maintenance, which are more feasible to adopt by SMEs.

Moreover, the feasible lean practices implementation can be a first step for SMEs to become lean enterprise (Meier & Forrester 2002). A number of studies have been performed in the context of feasible lean practices for SMEs and the list of such practices and their appearance in the literature has been given in the table 2.4.

Table 2.4: Lean practices for SMEs from literature.

Lean Practices for SMEs	Authors
Kaizen events	Bonavia and Marin (2006), White et al, (1999), Ahmad et al, (2009)
Quality certification (eg. ISO)	Rose et al, (2011), Bonavia and Marin (2006), Karim et al, (2011) , Ahmad et al, (2009)
Work standardization	Rose et al, (2011), Real et al, (2007), Bonavia and Marin (2006), Yauch and Steudel (2002), White et al, (1999) , Ahmad et al, (2009)
Visual management	Rose et al, (2011), Bonavia and Marin (2006) , Yauch and Steudel (2002), White et al, (1999) , Ahmad et al, (2009)
Value stream mapping (VSM)	Rose et al, (2011), Bonavia and Marin (2006), Karim et al, (2011), Ahmad et al, (2009)
Error proofing (Poka yoke)	White et al, (1999) , Ahmad et al, (2009)
Cellular layout	Rose et al, (2011) , Yauch and Steudel (2002), White et al, (1999) , Ahmad et al, (2009)
Total productive maintenance (TPM)	Yauch and Steudel (2002) , Ahmad et al, (2009)
Continuous improvement program	Rose et al, (2011), Karim et al, (2011), White et al, (1999) , Ahmad et al, (2009)
One piece flow	Rose et al, (2011), Real et al, (2007), Karim et al, (2011), White et al, (1999) , Ahmad et al, (2009)
Workplace organization (5S)	Rose et al, (2011), Real et al, (2007) , Yauch and Steudel (2002), Karim et al, (2011), White et al, (1999) , Ahmad et al, (2009)
Energy management	Ahmad et al, (2009)
Changeover reduction (SMED)	Rose et al, (2011), Real et al, (2007), Bonavia and Marin (2006), Karim et al, (2011), White et al, (1999) , Ahmad et al, (2009)
Pull/Kanban	Rose et al, (2011) , Yauch and Steudel (2002), Karim et al, (2011), White et al, (1999) , Ahmad et al, (2009)
PDCA problem-solving	White et al, (1999) , Ahmad et al, (2009)
Process mapping	Yauch and Steudel (2002) , Ahmad et al, (2009)
Benchmarking	Karim et al, (2011), White et al, (1999),Ahmad et al, (2009)
Six Sigma	Bonavia and Marin (2006), Karim et al, (2011) , Ahmad et al, (2009)
Environmental management	White et al, (1999) , Ahmad et al. (2009)
Just-in-time (JIT)	Karim et al, (2011), White et al. (1999) , Ahmad et al. (2009)

2.6 Critical Success Factors of Lean

Like any other productivity improvement practices, lean manufacturing also faces lots of difficulties in implementation (Denton and Hodgson, 1997).Several researchers have pointed out the difficulties and barriers in implementation of Just-in-time which is one of the many lean manufacturing practices Safayeni et al. (1991).

According to Hayes (2000), there should be proper planning before implementation of productivity improvement initiatives like lean manufacturing. Before implementing lean manufacturing, important aspects should be deeply considered, known as critical factors which will lead to successful implementation of Lean manufacturing. Rokart (1979) defines critical success factors as "areas in which results, if they are satisfactory, will ensure successful competitive performance for the organization".

Meanwhile, another author Saraph et al. (1989) defines CSF as "critical areas of managerial planning and actions that must be practiced in order to achieve effectiveness in a business unit". Similarly, Achanga et al. (2006) forced the presence of critical success factors for successful implementation of lean manufacturing. Successful new management system can be achieved by striving for critical success factors Saleheldin (2009).

Supporting it, Kumar and Antony (2008) highlighted that success and failure of an organization depends on the practices of critical success factors such as Management involvement and commitment, education and training of the employees at all level and customer management. For successful lean implementation, these managerial practices and critical success factors should be the top consideration for the organizations (Yusof and Aspinwall, 2000).

Based on thoroughly reviewed literature review, critical success factors for lean manufacturing highlighted by different authors are listed down in the table 2.5.

Table 2.5: Critical success factors from literature.

Authors	Critical Success Factors
Torbjørn (2016)	Commit, lead and be involved, Train and educate, Have a plan and follow it up, Allocate resources and share gains, Apply lean tools and methods
Achanga et al., (2006)	Leadership and management, Financial capabilities. Skills and expertise, Organizational culture, Trainings
Kumar and Antony (2008)	Management involvement and commitment, Communication, Link Quality initiatives to employee, Cultural change, Education and training, Link Quality initiatives to customer, Project selection, Link Quality initiatives to business, Link Quality initiatives to supplier, Project management skill, Organizational infrastructure, Vision and plan, IT and innovation
Motwani (2003)	Senior Management Support, Training and education, Customer involvement, Culture of organization, Communication channels, Encourage Employees, Information technology, Knowledge sharing
Ferdousi et al, (2009)	Cultural change , Education of workers and suppliers ,Empowerment of employees , Commitment of top level managers , Relationship with suppliers , Create awareness
Yauch and Steudel (2002)	Management support and political sponsorship, Clear performance criteria, Effective measurement system, Effective communication and involvement, Effective rewards and incentives, Effective resource utilization, Empowerment
Rose et al. (2011)	Teamwork, Supplier management, Training, Total Quality Management, Continuous improvement
Real et al. (2007)	Management leadership and commitment, Cultural change
Coronado and Antony (2002)	Management involvement and commitment, Culture Change, Organizational infrastructure, Communication, Training, Customer involvement, Human Resource, Supplier involvement, Project management skills, Understanding lean tools and techniques
Henderson and Evans (2000)	Upper management support/involvement, Organizational infrastructure, Training, Proper Tools and Techniques, Early communication to employees, Measurement systems, Information technology infrastructure, Human resources-based actions
Bandyopadhyay and Jayaram (1995)	Top management commitment, Dynamic organization structure, Training program for employees, Develop and maintain effective communication

Table 2.5 (Continued): Critical success factors from literature.

Authors	Critical Success Factors
McLachlin (1997)	Education and training, Employee involvement, Group performance measures, Teamwork, Top management commitment, Job security considerations
Hayes (2000)	Use of technology, Organizational culture, Availability of people
Sanchez and Perez (2001)	Multifunctional teams, Supplier integration, Continuous improvement, JIT production and delivery
Bambe and Dale (2000)	Management support and understanding, Sufficient training, Education and training, Involvement of people, Measure of performance, Time allocation for implementation
Germain and Droge (1997)	Improving Quality, Involvement of Suppliers and Customers, Organizational Design
Karlsson and Ahlstrom (1996)	Continuous improvement, Elimination of waste, Zero defects, Just-in-time, Multifunctional teams, Decentralized responsibilities, Integrated functions, Vertical information systems
Promporn (2014)	Balanced incremental development, Standardization of processes, Supportive leadership, Cross-functional teams, Employee development, Supplier involvement, Continuous improvement, Enhancement of creativity

The critical success factors mentioned by the researchers are summarized in table 2.6, Top Management commitment, Training and education, organizational culture and involvement of employees are the major critical success factors highlighted by authors and practitioners in Total Quality Management (TQM) and Lean manufacturing. Figure 2.1 shows the Achanga et al, (2006)'s model of successful implementation of lean practices which shows the most critical success factors for lean implementation are leadership and management with supporting elements as finances, organizational culture and skills and expertise.

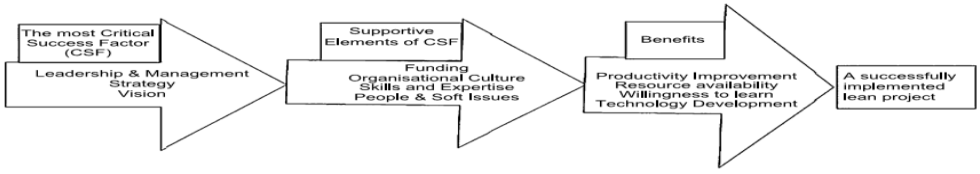

Figure 2.1: Elements of critical factors for a successful lean implementation (Source: Achanga et al, 2006).

Table 2.6: Critical Success Factors from literature (Summarized).

CSF	Motwani (2003)	Ferdousi et al, (2009)	Yauch and Steudel (2002)	Rose et al, (2011)	Real et al, (2007)	Coronado and Antony (2002)	Henderson and Evans (2000)	Bandyopadhyay and Jayaram (1995)	McLachlin (1997)	Hayes (2000)	Sanchez and Perez (2001)	Bambe and Dale (2000)	Lee and Ebrahimpour (1984)	Kumar amd Antony (2008)	Achanga et al, (2006)
Management commitment	✓	✓	✓		✓	✓	✓	✓	✓			✓	✓	✓	✓
Empowerment of employee		✓	✓												
Employee involvement	✓	✓	✓						✓	✓		✓		✓	
Training and education	✓	✓		✓		✓	✓	✓	✓			✓	✓	✓	✓
Effective communication	✓		✓			✓	✓	✓						✓	
Organizational culture	✓	✓			✓	✓		✓		✓				✓	✓
Feasible lean practices						✓	✓								
Human resource management			✓			✓	✓		✓					✓	
Continual evaluation measurement			✓				✓		✓			✓			
Quality management				✓											
Continuous improvement				✓							✓				
Customer management	✓					✓									
Supplier management		✓		✓		✓					✓		✓	✓	

Management involvement and commitment are perhaps the most essential factors in aiding desired improvement initiatives such as lean production (Coronado and Antony, 2002; Henderson and Evans, 2000; Kumar and Antony, 2008). Most of the authors support the idea of employee involvement which is key to the effective implementation of lean manufacturing (Lee and Ebrahimpour, 1984; Germain and Droge, 1997; McLachlin, 1997; Bandyopadhyay and Jayaram 1995). Successful lean implementation project requires working on creating a sustainable organizational culture (Achanga et al, 2006). Training and education which is another important factor for effective lean implementation is much needed which will help in reducing the resistance to change which exists because of traditional organizational culture (Womack and Jones, 1996; Karlsson and Ahlstrom, 1996; Bamber and Dale, 2000). Employees should be empowered to work on their improvement projects with heavy management support for to get effective and successful LM (Womack et al, 1990). Another important factor is to implement a continual evaluation measurement system which helps managers to take their decisions based on facts and figures instead of vague guesses (Yauch and Steudel, 2002; Henderson and Evans, 2000; McLachlin, 1997).

2.7 Benefits of Lean

According to Womack and Jones (1990) and White et al, (1999), any organization regardless of its size and maturity can get the benefits from lean manufacturing implementation. The main benefits highlighted in Melton (2005)'s study are reduction in inventory, reduced re-work, cost benefits, waste reduction, knowledge management improvement and lead time reduction. In support of it, Sohal et al. (1994) also indicates lean benefits such as competitive position in the market, financial savings, service quality and standardized process. On the other hand, Hanna (2007) indicates the change in the organizational thinking to solve a problem using capabilities and standardization. Peterson et al (2010) gives another aspect of lean benefits related to getting competitive position in the market by providing high quality product at shorter lead times by encouraging employee empowerment. Table 2.7 summarizes the lean benefits highlighted by different authors in their studies.

Table 2.7: Benefits of Lean from literature.

Authors	Journal	Benefits of Lean
Ferdousi and Ahmed (2009)	International Journal of Business and Management	Savings Resulting from Lean Practices, Reduction in Production Costs, Total Productivity Improvement, Reduction in Lead Time , Quality Improvement, Manufacturing Cycle Time reduction
White et al. (1999)	Management Science	Throughput Time Reduction, increase in Internal and External Quality Levels, Increased Labor Productivity, reduction in Inventory Levels, Reduction in manufacturing and administrative costs.
Sakakibara et al. (1997)	Management Science	Reduced cycle time, on time delivery, competitive advantage, set up time reduction, better supplier relationship, improved product design, Improved quality management, decreased cost of manufacturing, improved workforce management
Melton (2005)	Chemical Engineering Research and Design	Reduced inventory, Less re-work, Financial savings, Increased Process understanding, Less process waste, Reduced lead time
Sohal et al. (1994)	International Journal of Operations & Production Management	increased flexibility, lowering of cycle times, Greater sensitivity to market changes, Higher productivity levels, Stronger focus on performance, Improved supplier bonds, Changed from reactive to proactive organization, Increases in customer satisfaction, Co-operation of manufacturing personnel, Flexibility and efficiency of the plant, Company culture, Reduction in technical bottlenecks
Piercy and Rich (2009)	European Journal of Marketing	Operational cost reduction, Increased customer service quality
Flynn et al. (1999)	Academy of Management Journal	Reduced re-work time, Improved Just-in-time performance, Improved quality performance, Lot size reduction, Workforce management, Better supplier relationship
Fullerton et al. (2003)	Journal of Operations Management	Reduced setup times, Product quality improvement, Process quality improvement, reduced manufacturing cost
Papadopoulou and Ozbayrak (2005)	Journal of Manufacturing Technology Management	Improved quality, Better cash flow, Increased sales, Better productivity, Improved morale and higher profits

Table 2.8: Benefits of Lean from literature summarized.

Benefits	Womack and Jones (1990)	Liker (2004)	Ferdousi and Ahmed (2009)	White et al, (1999)	Sakakibara et al. (1997)	Sohal et al. (1994)	Piercy and Rich (2009)	Flynn et al. (1999)	Fullerton et al. (2003)
Decline in Purchasing Cost			X	X					
Increase in Productivity and Efficiency	X		X	X		X			
Achieving a more competitive position in the market					X	X			
Improvement in Product/Service quality	X		X	X	X		X	X	X
Improved profitability			X						
Reduced waste	X	X						X	
Reduced manufacturing/inventory cost	X	X	X	X	X		X	X	X
Increased customer satisfaction									
Culture change within the organization				X	X	X		X	
Increased Just-in-time Service	X	X	X	X	X	X		X	X
Improved Product Development					X				
Reduced Logistics cost			X	X	X				

2.8 Linking Lean Practices to Performance Benefits

Performance of any organization has been shifted from pure financial terms to include more business comprehensive terms (Neely et al, 2005). Although there are some areas where performance measures are useful but a little research has been done to give the guidelines about the appropriate measure to manage the business (Neely et al, 2000).

Lean practices are usually implemented at shop floor levels and the benefits are associated related to shop floor production process, so the non-financial measures for performance are useful to detect the performance of the organizations (Abdel-Maksoud et al, 2005). Lean companies are more likely to produce non-financial benefits which ultimately results in financial results and affects the business performance (Bartezzaghi and Turco, 1989; Chang and Lee, 1995; Jeyaraman and Leam, 2010).

Several studies have postulated the effects of Lean approaches on Operations performance and business performance. Operations performance is more about operating conditions of processes on shop floor and represents performance at each and every stage of the process, while Business performance is wider approach about looking at the performance of the business at higher scale. Operations performance is more related towards higher quality, decreased Inventory, improved lead time, high productions and cost reduction (Fullerton and Wempe, 2009; Shah and Ward, 2003.

On the other hand, the business performance is more related to higher profit, increased sale, and increased customer satisfaction(Green and Inman, 2007;Kannan and Tan, 2005). The objectives of Lean approaches affect both types of performances, Operations performance and business performance. The summary of the two types of performance, Operations performance and business performance, from the literature has been summarized in the table 2.9:

Table 2.9: Performance measures parameters from literature.

Performance Measurements	Flynn et al. (1999)	Chang and Lee (1995)	Sakakibara et al. (1997)	Claycomb et al. (1999)	Callen et al. (2000)	Fullerton and McWatters (2001)	Cua et al. (2001)	Chong et al. (2001)	Ahmad et al. (2009)	Shah and Ward (2003)	Ahmad et al. (2003)	Olsen (2004)	Green and Inman (2007)	Matsui (2007)	Abdallah and Matsui (2007)	Bhasin (2008)	Fullerton and Wempe (2009)
Operations Performance																	
Quality • Product Quality • Service Quality • First passed quality yields		¤	¤		¤	¤	¤	¤	¤	¤	¤			¤	¤	¤	¤
Inventory minimization • Reduction in inventory Level • Inventory turnover		¤	¤	¤	¤	¤		¤			¤		¤	¤	¤	¤	¤
Improved Lead Time • Timely delivery • fast delivery • Reduced Cycle Time			¤		¤		¤		¤		¤			¤	¤	¤	¤
Increased productivity • Workforce productivity • Machine productivity • Shop floor productivity							¤			¤	¤	¤				¤	¤
Cost reduction • Reduction in manufacturing cost • Reduction in quality cost		¤					¤	¤	¤	¤	¤			¤	¤	¤	
Business Performance																	
Increased Profitability • Improved profit margin • Increased return on investment		¤		¤	¤	¤					¤	¤	¤			¤	¤
Higher Sales • Growth in sales • higher market share		¤									¤	¤	¤			¤	
• **Customer satisfaction** Improved delivery lead time • Increased product quality • Improved responsiveness Competitive product • prices	¤		¤		¤			¤			¤	¤	¤	¤	¤	¤	

2.9 Definition of SME

SME" stands for small and medium-sized enterprises – as defined in EU law: EU recommendation 2003/361. The main factors determining whether a company is an SME are: number of employees and either turnover or balance sheet total. The category of micro, small and medium-sized enterprises (SMEs) is made up of enterprises which employ fewer than 250 persons and which have an annual turnover not exceeding EUR 50 million, and/or an annual balance sheet total not exceeding EUR 43 million. Within the SME category, a small enterprise is defined as an enterprise which employs fewer than 50 persons and whose annual turnover and/or annual balance sheet total does not exceed EUR 10 million. Within the SME category, a microenterprise is defined as an enterprise which employs fewer than 10 persons and whose annual turnover and/or annual balance sheet total does not exceed EUR 2 million.

Table 2.10: SMEs definition

Company category	Employees	Turnover	Balance sheet Total
Medium-sized	<250	≤ € 50	≤ € 43
Small	<50	≤ € 10	≤ €10
Micro	<10	≤ € 2	≤ € 2

2.10 Lean Production in SMEs

The literature is full of case studies involving Lean implementation in large organizations while a less research has been performed in terms of Lean implementation in small and medium size organizations. The small enterprises hesitate to go for lean system because they face a fear of having lack of resources, know-how, personnel, time and capital shortages (Matt and Rauch, 2013). Matt and Rauch (2013) suggested that it is not only possible to implement the lean principles in the small enterprises infect small enterprises can get all the lean benefits, advantages and improvements in terms of productivity and quality by reducing wastes and costs. There are specifically critical success factor for the Lean implementation in SMEs. Achanga et al, (2006) has identified critical success factors for the Lean implementation in SMEs in UK. The research concluded four key main factors for the successful implementation of Lean system in the organizations which are: *Leadership and management, Finance, Skills and*

expertise and culture of the organization. And among these factors, Leadership and management commitment were concluded as most critical factors for the successful implementation of the Lean projects in SMEs. The scope of Lean is not only subjected to the manufacturing industries. Dora et al, (2013) showed the lean implementation in the SMEs food industries in UK. The applications of Lean implementation are still evolving the food sector and it is still at an early stage of development.

Because the food SMEs are more focused on the food quality and food safety management methods and less on process improvement methods. Labor skills, in-house knowledge and expertise and organizational culture are found to be the most critical factors for the implementation of lean in food SMEs. Researchers also suggest that SMEs can get a large number of benefits from the Lean practices. Stamm and Golhar (1990) found that there are many benefits from lean practices that can be achieved better by small firms as compared to larger firms.

These benefits include smaller inventories, shorter lead times, improved quality, lower costs and reduced wastes. Infect some researchers suggest that smaller firms can have immediate befits from Lean practices as compared to larger firms which takes time to show the benefits. Some of the research studies related to lean implementation in SMEs and large organizations are summarized in the Table 2.11.

Table 2.11: Lean and SMEs studies from literature.

Author	Country	Type of Industry	No and Size of Industry	Method of Research	Focus and finding of Research
Şule and Büient (2003)	Turkey	Manufacturing	17 medium and large-scale companies	Survey Questionnaire Method	Production Management and Strategic Management
Zhou (2012)	USA	Manufacturing and Service	34/SMEs	Survey Questionnaire Method	Lean tools, benefits and CSF for lean implementation
Rose et al. (2014)	Malaysia	Manufacturing industries	97/SMEs and large	Survey Method	Identified CSF of lean for SMEs

Table 2.11 (Continued): Lean and SMEs studies from literature.

Author	Country	Type of Industry	No and Size of Industry	Method of Research	Focus and finding of Research
KARIM et al. (2011)	Saudi	Manufacturing industries	120/SMEs and large	Survey Method	Lean status in SMEs and the barriers
Bakas et al. (2011)	Norway and Belgium	Manufacturing industries	11/SMEs	joint workshops	CSF for Norwegian and Belgium SMEs
Rose et al. (2011)	Malaysia		SMEs	Literature review	Highlighted Feasible lean practices for SMEs
Khanchanapong et al. (2014)	Thailand	Manufacturing industries	186/Large	Survey Method	effect of lean practices on manufacturing operational performance
Mwelu et al. (2014)	Uganda	Manufacturing	80/Large	Survey Method	effect of lean manufacturing on profitability of the firms
Eswaramoorthi et al. (2011)	India	Manufacturing	43/Large	questionnaire based survey	Lean tools, benefits and Barriers faced by Indian SMEs
Taj (2005)	China	Manufacturing industries	65/Large	Survey Method	Evaluated the lean gap in the manufacturing practices within the organizations
Meier and Forrester (2002)	UK	Manufacturing industries	30/Large	Survey Questionnaire Method	Degree of lean and its relation with management commitment

There are many reasons why SMEs hesitates to adopt Lean practices in their systems. Researchers have pointed out lack of top management commitment, lack of financial resources, deficiency of specialized equipment, and lack of perception that lean production is a simple form of manufacturing control.

3. RESEARCH STRATEGY AND DATA COLLECTION

3.1 Research Methodology

The main objective of this research is to scrutinize the adoption of lean practices in SMEs in Pakistan. The purpose is to evaluate the awareness, implementation, critical success factors, barriers and perceived benefits of lean practices in SMEs in Pakistan. For this purpose the survey based data technique has been adopted and the questionnaire was distributed to the SMEs across Pakistan

Since the focus of the research is to explore the current practices, needs, benefits and barriers associated with the lean adoption in small medium enterprises, based on the SMEs definition which was adopted from European commission, in Pakistan so the sample of the research included a variety of companies including manufacturing, logistics, service and distribution.

The mailing list of 300 companies in manufacturing, service automobile and distribution sectors is prepared using personal contacts and also SMEs associations SMEDA (Pakistan).

The survey distribution was done through emails and the questionnaire was prepared on the website and the link to the website was attached in the mails along with the cover letter explaining the purpose of the research survey and its contribution the research.

The targeted personnel in the survey were managers, quality personnel, owners or industrial engineers in the SMEs which were more likely to know the answers to the questions and reliable to get the responses from them. After two weeks a reminder mail was sent again to get the better response rate.

Another follow up email was sent again to the non-respondents after four weeks requesting them to fill the survey.

Figure 3.1: Research Methodology

3.2 Research questionnaire

The questionnaire which was developed for the data collection purpose for this research consisted of a number of parts. The first part consisted of eight demographic questions to analyze company profile including information related to company name, job title of the respondent, organizations sector, type of ownership, operating locations of the company, number of years of lean practices and the awareness of different lean terms extracted from literature. The second part was focused towards the level of lean implementation in the company. For this purpose a number of commonly used lean tools were identified from previous research work (Kirby and Greene 2003, Czabke et al. 2008, Liker 2003) and a total of 20 tools were selected for the survey investigation. A five point Likert scale was used for this question with the options ranging from lean implementation to very high, high, medium, low, very

low scale. The perceived and actual benefits were listed in the third part of the survey and the organizations were asked to mention the benefits which they perceive or have actually noticed in their performances using lean practices. The fourth part listed down a number of barriers which an organization can face during lean implementation and the organizations were asked to identify the barriers which they have faced during lean practices implementation.

Finally the last part consisted of the critical success factors for the lean implementation and the organizations were asked about their point of view regarding the success factors of lean practices in their organization.

A five point Likert scale was used to measure the responses for third forth and fifth question with the options ranging from strongly agree, agree, neutral, disagree and strongly disagree. The purpose of using this scale was to force the respondents to give exclusive and decisive answers to the questions, also this type of scale makes it easy for the respondents to answer since it is less time consuming.

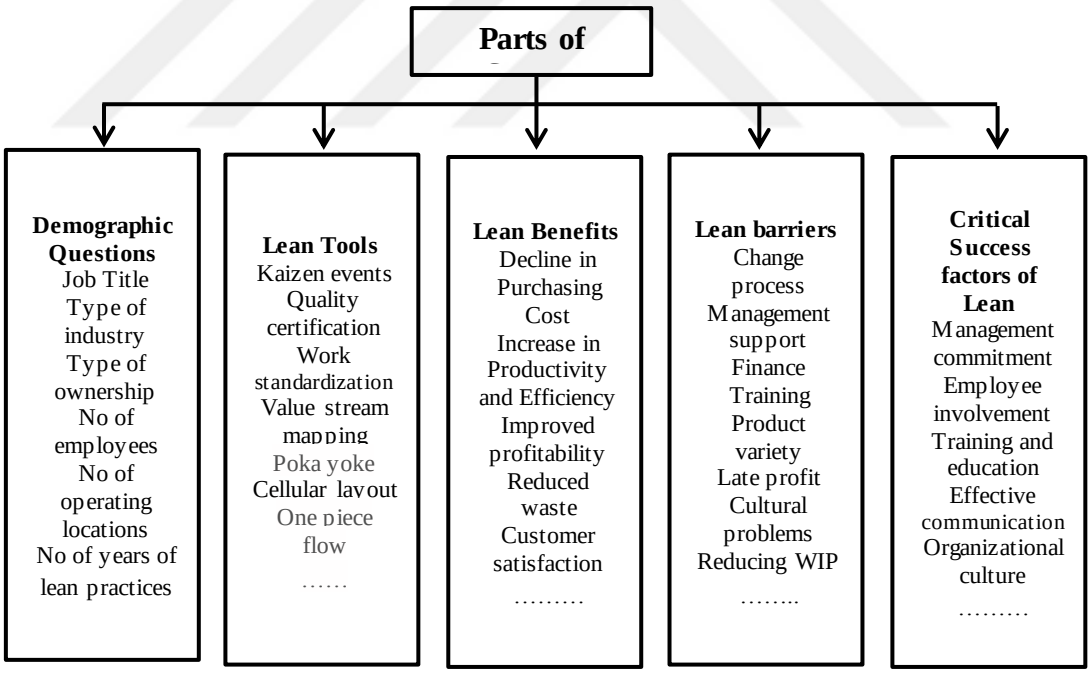

Figure 3.2: Questionnaire structure

The questionnaire contains total of 70 questions and we assumed that every question has equal weight age, the questions distribution is given in Table 3.1.

Table 3.1: Questionnaire structure and Section wise distribution

Section	No of Questions	Percentage
Company Profile	8	11 %
Lean Implementation	20	28 %
Lean Benefits	13	19 %
Lean Barriers	16	23 %
Critical Success factors for Lean	13	19 %
Total	70	100 %

4. RESEARCH FINDINGS AND ANALYSIS

A total of 300 companies were contacted for the survey participation. The survey was made on a commercial website and the companies were contacted through emails, the context of the emails was clarifying the objective of the research survey as well as the link of the survey to be filled. After two weeks the companies were contacted again for the better response and after four weeks another reminder mail was forwarded to the companies for their participation in the survey. After six weeks a total of 124 companies responded in total which shows a response rate of 42% which is quite acceptable for our analysis.

4.1 Descriptive Analysis

4.1.1 Questionnaire reliability analysis

To check the reliability of the questionnaire reliability tests are carried out on sample responses. Reliability test measures the internal consistency of the questionnaire, that is, how the set of items in a group are closely related. To measure this Cronbach's alpha is used in SPSS. In research, the value of Cronbach's alpha in the range of 0.6-0.7 are regarded as acceptable, above 0.7 is regarded as good and below 0.6 is regarded as poor (Sakakibara et al 1999). As shown in Table 4.1, the Cronbach's alpha value for different areas of the survey are above 0.7, which means the data is reliable considering more than 0.6 as the limit value for acceptance condition.

Table 4.1: Reliability Test

Item	No of items included	Cronbach's alpha value	Skewness	Kurtosis
Lean Tools	20	0.965	- 0.17	- 1.04
Lean Benefits	13	0.721	0.70	0.86
Lean Barriers	16	0.660	0.14	0.46
Lean CSF	13	0.768	- 0.47	0.12

4.1.2 Demographics of the respondent companies

The purpose of first part of our survey was to collect the data regarding companies' background information including industrial segment to which the company belongs, type of ownership, No of employees in the company, no of operating locations and total no of years of lean implementation and practices. Following tables shows the summary of the responses collected.

In terms of type of industry to which SMEs belong, more than half of the respondents companies, i.e. 70.16 percent, are manufacturing companies which includes, automobile, metal goods, paper and packaging, chemicals, textiles, food and drinks, electrical components pharmaceuticals and other manufacturing, while around 30 percent of companies are in service sectors which includes distributions, warehousing and consumer services.

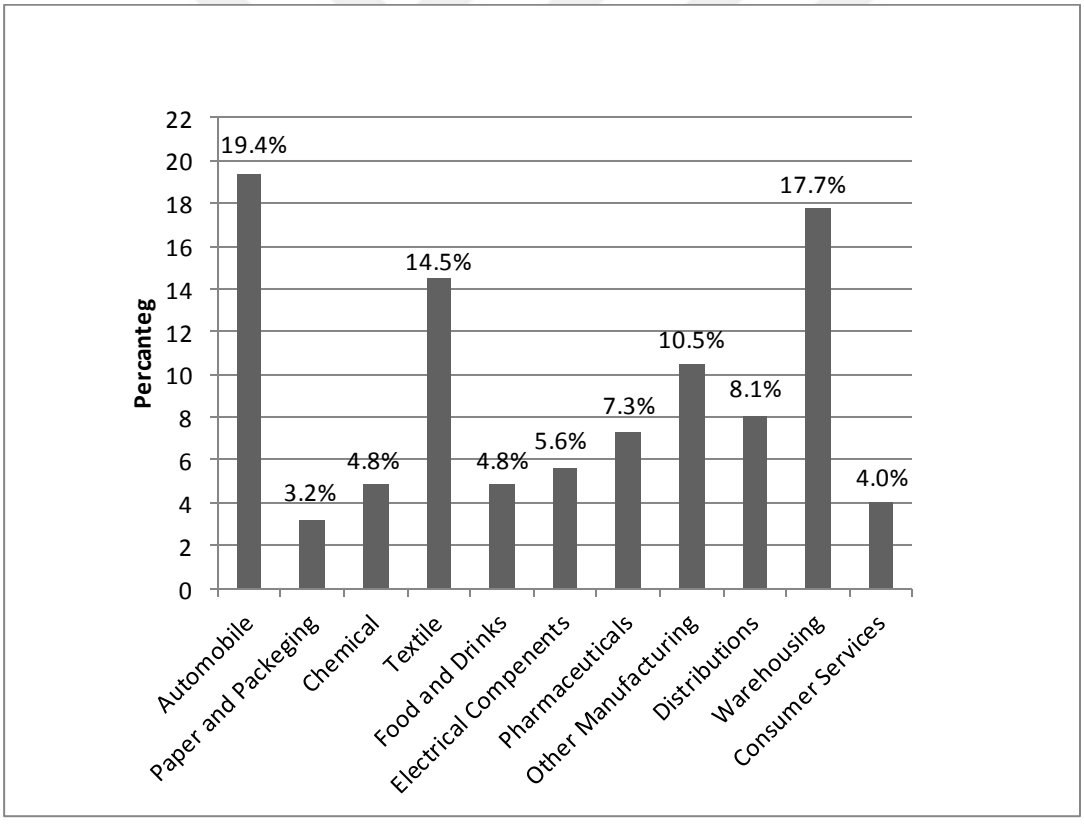

Figure 4.1: Sector wise distribution of SMEs

According to the results of type of ownership, 73.4 percent companies are privately owned and the percentage of publicly owned SMEs is 26.6 percent. Which shows mostly the SMEs in Pakistan are privately owned companies.

Table 4.2: Type of ownership

Item	Frequency	Percent
Private	91	73.4
Public	33	26.6
Total	**124**	**100**

As par European commission definition of SMEs, the maximum number of employees in an enterprise should be less than 250. Based on this definition the results in our survey shows 5.6 percent of companies having less than 10 employees, 33.1 percent of companies comprises of 10-49 employees and 61.3 percent of responses fall in the category of 50-249 employees**.**

Table 4.3: No of employees

Item	Frequency	Percent
Less than 10	7	5.6
10-49	41	33.1
50-249	76	61.3
Total	**124**	**100**

In terms of no of operating locations, research shows that more than two third of the companies comes in the category of 1-3 locations while 11.3 percent companies have more than 4 locations.

Table 4.4: No of operating Locations

Item	Frequency	Percent
1-3	110	88.7
4-6	14	11.3
7 and above	0	0
Total	**124**	**100**

The research was also aimed to get to know the lean practices and experiences timespan in SMES. Our results indicate that more than half (52.42 percent) of companies have less than 3 years of lean practices and experience, 28 percent of respondent companies have 3 to 6 years of lean experience, while only 8.87 percent SMEs have more than 6 years of lean practices. Furthermore 10.48 percent of SMEs have not implemented lean practices at all.

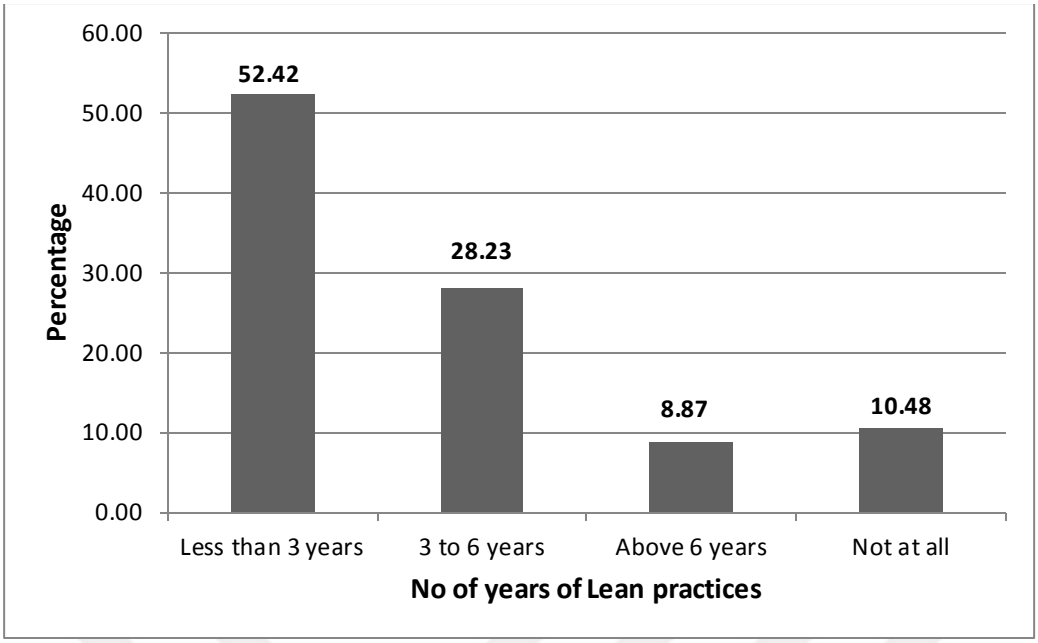

Figure 4.2: Years of Lean Practices

4.2 LEAN IMPLEMENTATION STATUS

To analyze the lean implementation status in SMEs in Pakistan, the respondent companies were asked to rate 20 most common lean tools on a scale of 1 to 5 where 1 representing very low implementation of that tool and 5 being very high implementation of that lean tool in that company. The results obtained from the survey were analyzed with the help of SPSS software and the summary of the mean and standard deviation of 20 lean tools is shown in the Table 4.5 below. The interesting findings from the results is that most of the companies are preferring Quality certification (ISO) as the highest implemented lean tool with the mean value of 3.66. Following quality certification, workplace organization (5S), work standardization and process mapping are the next three highly implemented lean tools in SMEs in Pakistan with mean values of 3.64, 3.60 and 3.36 respectively, which emphasizes that SMEs in Pakistan are more inclined towards the standardization of their working systems, procedures to get the optimum and best results in first time. On the other hand, the least common tools within SMEs structure in Pakistan are Six Sigma, Changeover reduction (SMED) and Pull/Kanban with mean values of 2.32, 2.30 and 1.97 respectively. The explanation of less adoption of these tools could be that most of the SMEs in Pakistan are in early stage of Lean implementation while the Six Sigma or SMED are more comprehensive tools and need more experience and skills to get the benefits from these tools.

Table 4.5: Lean Tools

Item	Rank	Mean	Std. Deviation	Variance
Quality certification (eg. ISO)	1	3.66	1.343	1.803
Workplace organization (5S)	2	3.64	1.192	1.420
Work standardization	3	3.60	1.147	1.316
Process mapping	4	3.36	1.205	1.453
Continuous improvement program	5	3.31	1.258	1.583
Just-in-time (JIT)	6	3.19	1.305	1.702
Visual management	7	3.00	1.148	1.317
Kaizen events	8	2.97	1.425	2.031
One piece flow	9	2.85	1.127	1.269
Value stream mapping (VSM)	10	2.75	1.323	1.750
Error proofing (Poka yoke)	11	2.71	1.065	1.135
Cellular layout	12	2.61	1.348	1.816
Energy management	13	2.60	1.147	1.316
Total productive maintenance	14	2.48	1.172	1.374
PDCA problem-solving	15	2.48	1.303	1.699
Benchmarking	16	2.38	1.247	1.554
Environmental management	17	2.36	1.345	1.810
Six Sigma	18	2.32	1.316	1.732
Changeover reduction (SMED)	19	2.30	1.140	1.300
Pull/Kanban	20	1.97	.910	.828

The results for the mean values of 20 most common lean tools do not show the detailed picture of the adoption of lean tools. As some of the lean tools have high mean value up to 3.66 while some of the tools have very low mean value about 1.97, which means there are some of the companies which have high implementation of lean tools and few companies with no experience of lean tools at all. To get the better picture of which lean tools were mostly implemented in which companies Box and Whisker plot technique was used.

4.2.1 Analysis of implementation of lean tools based on the number of years of lean practices

The individual lean tools were analyzed based on the number of years of lean practices in the SMEs using Box and Whisker plots. Figure-4.3 shows the results for the Kaizen lean tool. From the box and whisker plot it is clear that the Kaizen is mostly implemented in the SMEs having more than 3 years of experience. Contrary to that it has very low implementation level in the companies having No lean implementation at all. Whereas, The companies having less than 3 years of

experience have 50 percent higher level and 50 percent lower level of lean implementation.

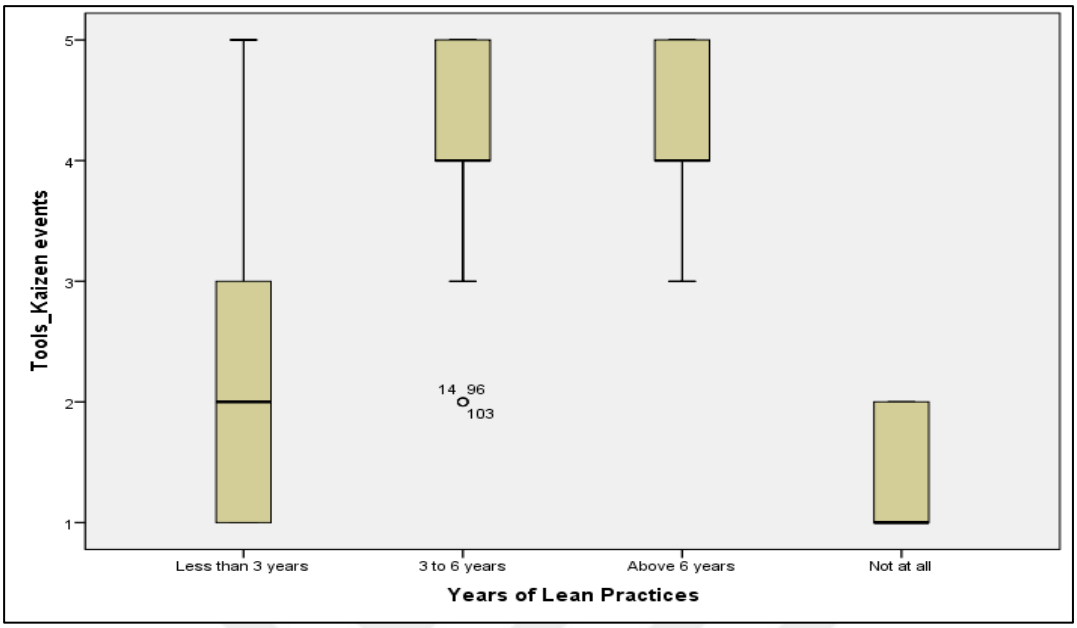

Figure 4.3: Kaizen implementation based on Lean experience

If we look at the Box and Whisker plot of Quality certification (Figure-4.4) then it shows that all the SMEs which having more than 6 years of Lean experience have adopted this tool at the highest level, and similarly, the companies having 3 to 6 Years of lean experience having high to very high implementation of Quality certification. On the other hand, the SMEs having less than three years of Lean experience shows a wide range of the results. More than 25 percent of the companies have high to very high implementation whereas the rest of the companies have averages to low level of implementation of Quality certification. The SMEs having no experience of Lean at all also shows some strange results because 50 percent of the companies are showing high level of Quality certification implementation which can be because of the reason that mostly customers buy products from those companies which are ISO certified, So though these companies don't follow much ISO certifications but still they adopt it to attract more customers.

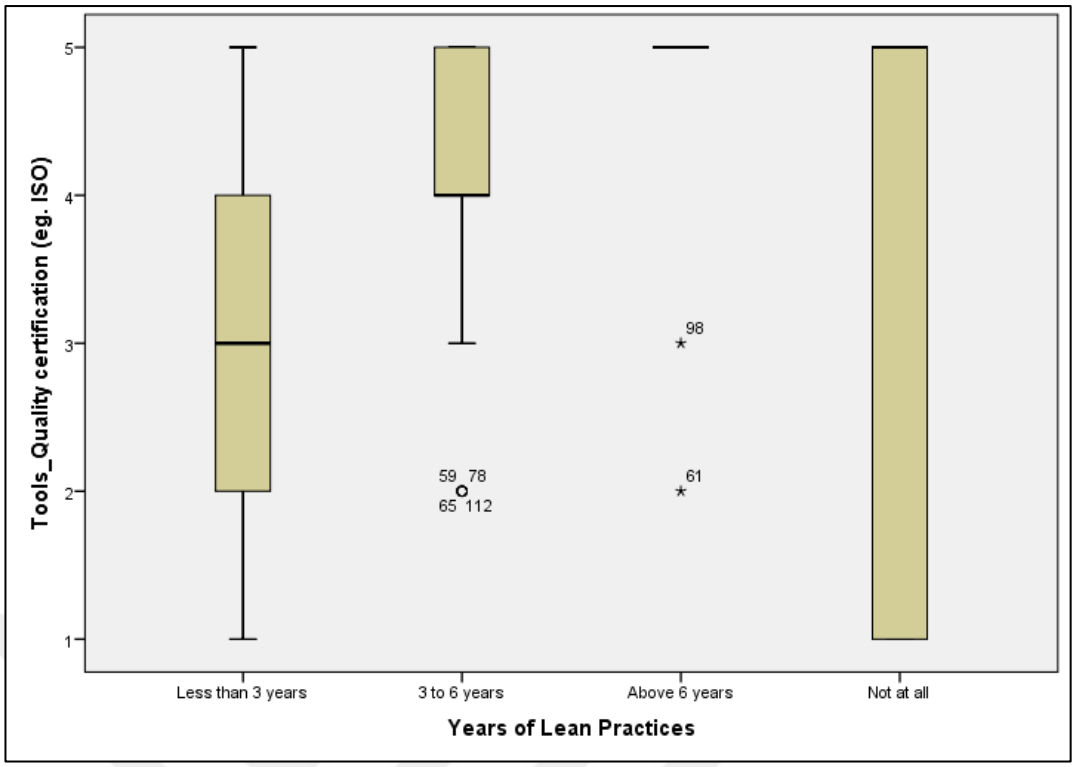

Figure 4.4: Quality certification based on Lean experience

Figure-4.5 shows the Box and Whisker plot for the Work standardization lean tool, which shows the same results that SMEs having no lean experience at all have average to low level of implementation of work standardization.

SMEs having less than 3 years of lean experience show a wide range from low to very high level of implementation of this tool; more than 50% of the companies have very high level of implementation.

The SMEs having 3 to 6 years of experience shows one fourth of the companies having very high implementation whereas three fourth of the companies have average to high level of implementation. This is quite similar in the case of SMEs which having more than 6 years of lean experience.

Figure 4.5: Work standardization based on Lean experience

The rest of the tools were also plotted on box and whiskers plots shown in the respective figures i.e. Visual Management (Figure-4.6), Value Stream Mapping (Figure-4.7), Error Proofing (Figure-4.8), Cellular Layout (Figure-4.9), Productive Maintenance (Figure-4.10), Continuous Improvement (Figure-4.11), One piece Flow (Figure-4.12), Workplace organization (Figure-4.13), Energy Management (Figure-4.14), Changeover reduction (Figure-4.15), Pull/Kanban (Figure-4.16), PDCA Problem Solving (Figure-4.17), Process Mapping (Figure-4.18), Benchmarking (Figure-4.19), Six Sigma (Figure-4.20), Environmental Management (Figure 4.21) and Just-in-time (Figure-4.22).

The plots shows that the companies having more than 6 years of experience have very high implementation of almost all lean tools except: change over reduction (SMED) where half of the SMEs have low to average level of implementation of this tool, also in Pull/Kanban tool 1/2of the SMEs have average to low level of implementation and PDCA one fourth of the SMEs have less than average level of implementation of this tool.

The SMEs which having three to six years of lean experience shows high to very high level of implementation of most of the lean tools. In case of visual management almost all of the SMEs in this category show high level of implementation of this tool. More than half of SMEs in this category shows high to very high level of implementation of value stream mapping tool. Same is in the case of error proofing tool where 50 percent of the SMEs shows high level of implementation of this tool.

On the other hand the tools such as cellular layout, Total Productive Maintenance, One piece Flow, changeover reduction (SMED), Pull/Kanban, Problem Solving (PDCA) and Benchmarking shows half of the SMEs having below average implementation of these tools especially changeover reduction (SMED) in which one fourth of the SMEs have very low implementation of this tool.

The companies having less than three years of lean implementation experience shows a vide variety of lean tools implementation status in which some of the lean tools have very high, some on average and some on very low level of implementation.

The companies having no experience of lean at all show very low or below average of lean tools implementation status. Specifically, the lean tools such as Value stream mapping, Cellular layout, Total Productive Maintenance, Energy Management, Pull/Kanban, PDCA Problem Solving, Benchmarking, Six Sigma and Environmental management showing very low level of implementation of these tools.

4.2.2 Analysis of implementation of lean tools based on the company sector

The box and whisker for overall lean tools implementation based on company sector was drawn using SPSS data set (Figure-2.24). The plot shows that different types of SMEs show different levels of lean implementation. Mostly lean tools are highly implemented in Automobile, Pharmaceuticals, Textiles and consumer services where more than half of the SMEs in these categories have above average to high level of lean implementation.

The type of SMEs showing below average or low level of lean implementation status includes Paper and Packaging, Chemicals, Food & Drinks, Electrical components and warehousing where more than 50 percent of these type of SMEs shows low level of lean implementation.

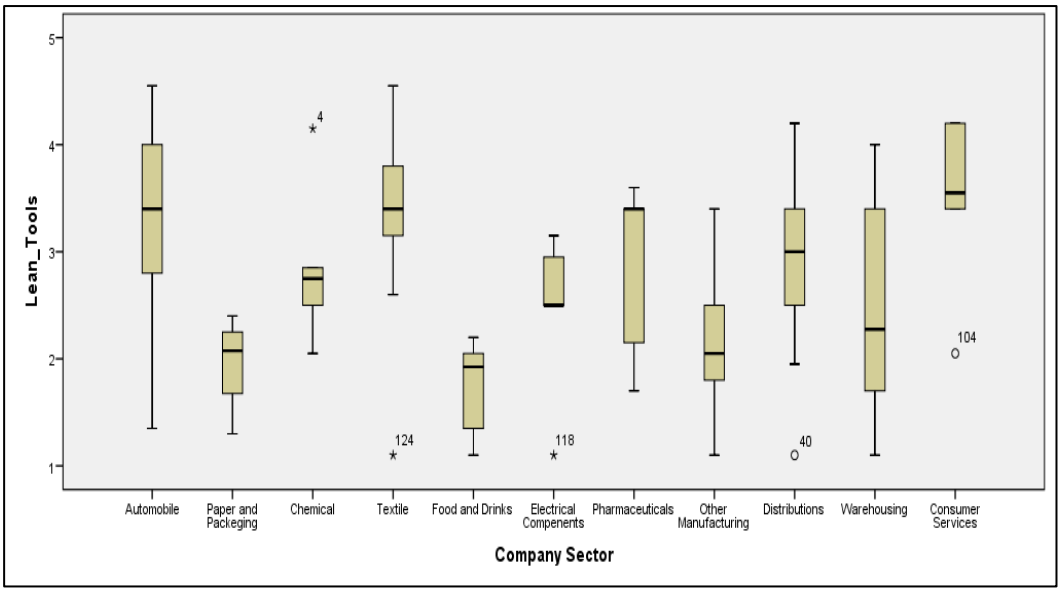

Figure 4.24: Lean implementation based on Company sector

4.2.3 Analysis of implementation of lean tools based on type of ownership

Lean tool implementation was also analyzed based on type of ownership of the SMEs shown in figure-4.25. Both type of SMEs shows almost same trend in terms of level of lean tools implementation. Almost one fourth of Private SMEs shows high to very high level of lean implementation status and more than 50 percent of private SMEs have above average lean implementation status. Same is in the case of public SMEs i.e. more than half of these types of SMEs have above average of lean implementation but none of these SMEs shows very high level of lean implementation status.

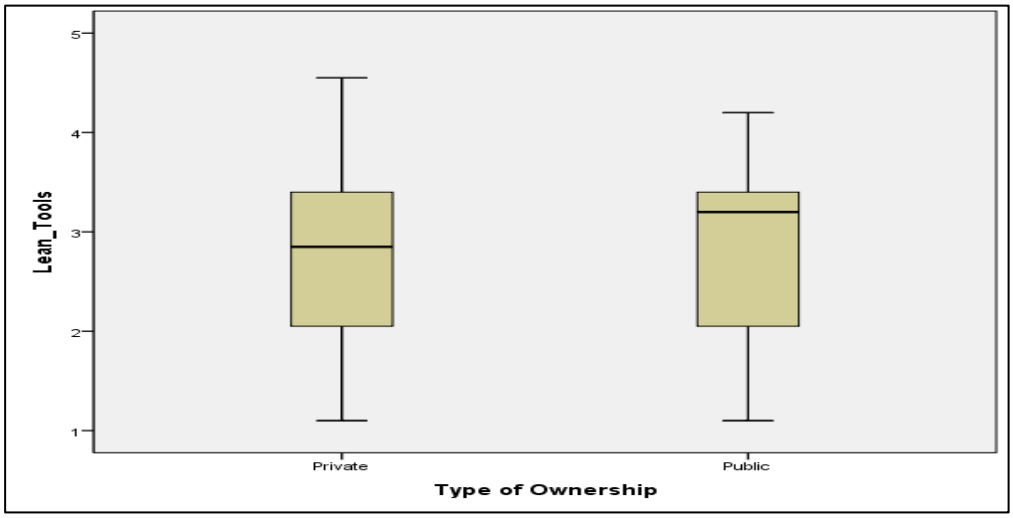

Figure 4.25: Lean implementation based on Type of ownership

The box and Whisker plots used in the above section are just for the information purpose and to get the better picture of the results and analysis.

To get the better picture of the results, the data was distributed into cluster to do cluster analysis. SPSS software was used to do hierarchical cluster analysis using squared Euclidean distance method for the lean tools variables. On the basis of cluster analysis the data was segmented into three clusters based on the values of lean tools, named as Highly Lean Companies (cluster 1), Somewhat Lean companies (cluster 2) and Not at all Lean Companies (cluster 3).

4.2.4 Highly Lean Companies (Cluster 1)

Based on the cluster analysis, about 42 percent of the respondent companies lie in the category of lean companies. These are the companies which have high mean values of different lean tools. As shown in the Table 4.6, the mean values of different lean tools range from 4.38 maximum and 2.62 as minimum. These values are definitely higher the previous values where the cluster analysis was not applied. Based on the results, these highly lean implemented companies have workplace organization, work standardization, continuous improvement program, process mapping and kaizen events as highly implemented lean tools. Quality certification comes after all these tools. Because the basic purpose of lean is not get certified without doing minor improvements in the systems. These results show that the lean companies focus on the overall effectiveness and efficiency of the systems.

Table 4.6: Lean tools applied with hierarchical cluster analysis, cluster one.

Cluster one: Highly Lean group (n = 52, 42 %)				
Tools	**Rank**	**Mean**	**Std. Deviation**	**Variance**
Workplace organization (5S)	1	4.38	.565	.320
Work standardization	2	4.33	.734	.538
Continuous improvement program	3	4.15	.668	.446
Process mapping	4	4.08	.479	.229
Kaizen events	5	4.02	.727	.529
Just-in-time (JIT)	6	3.98	.610	.372
Quality certification (eg. ISO)	7	3.96	1.328	1.763
Visual management	8	3.96	.484	.234

Table 4.6 (Continued): Lean tools applied with hierarchical cluster analysis, cluster one

Cluster one: Highly Lean group (n = 52, 42 %)				
Tools	**Rank**	**Mean**	**Std. Deviation**	**Variance**
Cellular layout	9	3.85	.849	.721
Benchmarking	10	3.69	.579	.335
Environmental management	11	3.65	1.008	1.015
Value stream mapping (VSM)	12	3.58	.825	.680
Total productive maintenance (TPM)	13	3.54	.803	.646
Six Sigma	14	3.50	1.000	1.000
Error proofing (Poka yoke)	15	3.46	.576	.332
Changeover reduction (SMED)	16	3.38	.796	.633
Energy management	17	3.23	.614	.377
One piece flow	18	3.12	.511	.261
PDCA problem-solving	19	3.12	.963	.928
Pull/Kanban	20	2.62	.889	.790

The research of Kirby and Greene's (2003) has concluded that the organizational lean maturity and number of implemented lean tools depends upon the number of years of lean practice. As in the case of cluster one i.e. Lean companies, Table 4.7 shows that more than 44 percent of companies are practicing lean tools from 3 to 6 years and about 21 percent of companies have more than 6 years of lean experience, while around 35 percent of companies have recently adopted lean tools. This result emphasizes that more the experience of lean practices and more maturity in terms of lean tools.

Table 4.7: Years of Lean Practices (Cluster 1)

	Frequency	**Percent**	**Cumulative Percent**
Less than 3 years	18	34.6	34.6
3 to 6 years	23	44.2	78.8
Above 6 years	11	21.15	100.0
Not at all	0	0	
Total	52	100.0	

4.2.5 Somewhat Lean Companies (Cluster 2)

27 percent of respondent companies come in the middle category. Specifically 33 companies are regarded as "Somewhat Lean companies. These are the companies which are in the early adoption stage of lean practices and slowly tending towards the maturity level of lean implementation. The mean value of lean tools in these companies have high value as 4.21 (workplace organization) while as low as 1.58

(change over reduction SMED) which shows that some of the tools have been highly implemented while the more comprehensive tools are still in the process of maturity (Table-4.8). The most common highly implemented tools in this category are Workplace organization (5S), Quality certification (e.g. ISO), Process mapping and Work standardization, as the early adopters start practicing lean tools which are easy to stat and implement.

Table 4.8: Lean tools applied with hierarchical cluster analysis, cluster Two

Cluster Two: Somewhat Lean group (n = 33, 27 %)				
Tools	**Rank**	**Mean**	**Std. Deviation**	**Variance**
Workplace organization (5S)	1	4.21	.820	.672
Quality certification (e.g. ISO)	2	4.03	.305	.093
Process mapping	3	4.03	.770	.593
Work standardization	4	4.00	.354	.125
Continuous improvement program	5	3.61	.966	.934
Value stream mapping (VSM)	6	3.30	.918	.843
Kaizen events	7	3.27	1.180	1.392
Visual management	8	3.06	.747	.559
One piece flow	9	2.97	1.425	2.030
Energy management	10	2.97	1.311	1.718
PDCA problem-solving	11	2.94	1.435	2.059
Just-in-time (JIT)	12	2.61	.556	.309
Error proofing (Poka yoke)	13	2.58	.969	.939
Cellular layout	14	2.36	.783	.614
Total productive maintenance (TPM)	15	2.30	.529	.280
Pull/Kanban	16	1.94	.496	.246
Six Sigma	17	1.88	.857	.735
Environmental management	18	1.73	.574	.330
Benchmarking	19	1.64	.549	.301
Changeover reduction (SMED)	20	1.58	.614	.377

As far as the year of lean practices is concerned, the “somewhat lean” companies are the early adopters of lean and therefore more than half of the companies (63.6 percent) or more specifically 21 companies are practicing lean for less than 3 years (Table-4.9). Around 36.3 percent companies have implemented lean for 3 to 6 years. This results support the research of Kirby and Greene’s (2003) that the maturity of lean depends upon the number of years of lean practicing.

Table 4.9: Years of Lean Practices (Cluster 2)

	Frequency	Percent	Cumulative Percent
Less than 3 years	21	63.6	63.6
3 to 6 years	12	36.3	100.0
Above 6 years	0	0.0	100.0
Not at all	0	3.0	100.0
Total	33	100.0	

4.2.6 Not at all Lean Companies (Cluster 3)

The Table 4.10 represents the last cluster which was "Not at all Lean" companies. About one third of the respondent companies, fall in this cluster. These are the companies which have not implemented lean at all or have just implemented few lean tools without knowing about Lean practices in detail. Quality certification (e.g. ISO), Just-in-time (JIT), One piece flow, Work standardization, Workplace organization (5S) are highly implemented lean tools in these companies as these are the tools which are easy to adopt and implement.

The SMEs focus on getting Quality certification as early as possible because the customers prefer those companies which are certified with international standards but getting certified doesn't mean these companies are practicing all the lean tools. As seen in the table below, the least implemented lea tools are pull/Kanban and Six Sigma because these are the tools which need detailed study of the system and they require continuous effort and financial stability to get the benefits from these tools.

Table 4.10: Lean tools applied with hierarchical cluster analysis, cluster Three

Cluster Three: Somewhat Lean group (n = 39, 31 %)				
Tools	**Rank**	**Mean**	**Std. Deviation**	**Variance**
Quality certification (eg. ISO)	1	2.95	1.621	2.629
Just-in-time (JIT)	2	2.64	1.814	3.289
One piece flow	3	2.38	1.310	1.717
Work standardization	4	2.28	.887	.787
Workplace organization (5S)	5	2.15	.540	.291
Continuous improvement program	6	1.95	.887	.787
Process mapping	7	1.85	.670	.449

Table 4.10 (Continued): Lean tools applied with hierarchical cluster analysis, cluster Three

Cluster Three: Somewhat Lean group (n = 39, 31 %)				
Tools	**Rank**	**Mean**	**Std. Deviation**	**Variance**
Error proofing (Poka yoke)	8	1.82	.914	.835
Visual management	9	1.67	.621	.386
Changeover reduction (SMED)	10	1.46	.505	.255
Energy management	11	1.44	.502	.252
Kaizen events	12	1.31	.521	.271
Benchmarking	13	1.26	.442	.196
Total productive maintenance (TPM)	14	1.23	.427	.182
PDCA problem-solving	15	1.23	.427	.182
Value stream mapping (VSM)	16	1.18	.556	.309
Cellular layout	17	1.18	.389	.151
Environmental management	18	1.18	.389	.151
Pull/Kanban	19	1.13	.339	.115
Six Sigma	20	1.13	.339	.115

As the cluster 3 is comprised of the companies which are not aware of lean at all or have implemented some lean tools without any detailed knowledge and understanding of lean. Table 4.11 also shows that one third of the companies in this category have not implemented lean at all while 26 companies (66.7 percent) have less than three years of lean experience . these are companies which have implemented some of the Lean tools without understanding their importance in Lean thinking. The results of above three clusters show that the lean maturity and the number of lean tools implemented in a company have a direct relationship with the number of years of lean practice sin the company.

Table 4.11: Years of Lean Practices (Cluster 3)

	Frequency	**Percent**	**Cumulative Percent**
Less than 3 years	26	66.7	66.7
3 to 6 years	0	0.0	66.7
Above 6 years	0	0.0	66.7
Not at all	13	33.3	100.0
Total	39	100.0	

The Figure 4.26 gives the summary of cluster analysis of lean tools implementation in SMEs in Pakistan. Cluster 1 represents Highly Lean companies, also in the graph the mean values of lean tools in cluster one is high as companies as compared to

other two cluster. Cluster two represents middle level of lean adopting companies with average values of lean tools in this cluster while cluster three represents not at all lean companies with very low mean values of lean tools in this category.

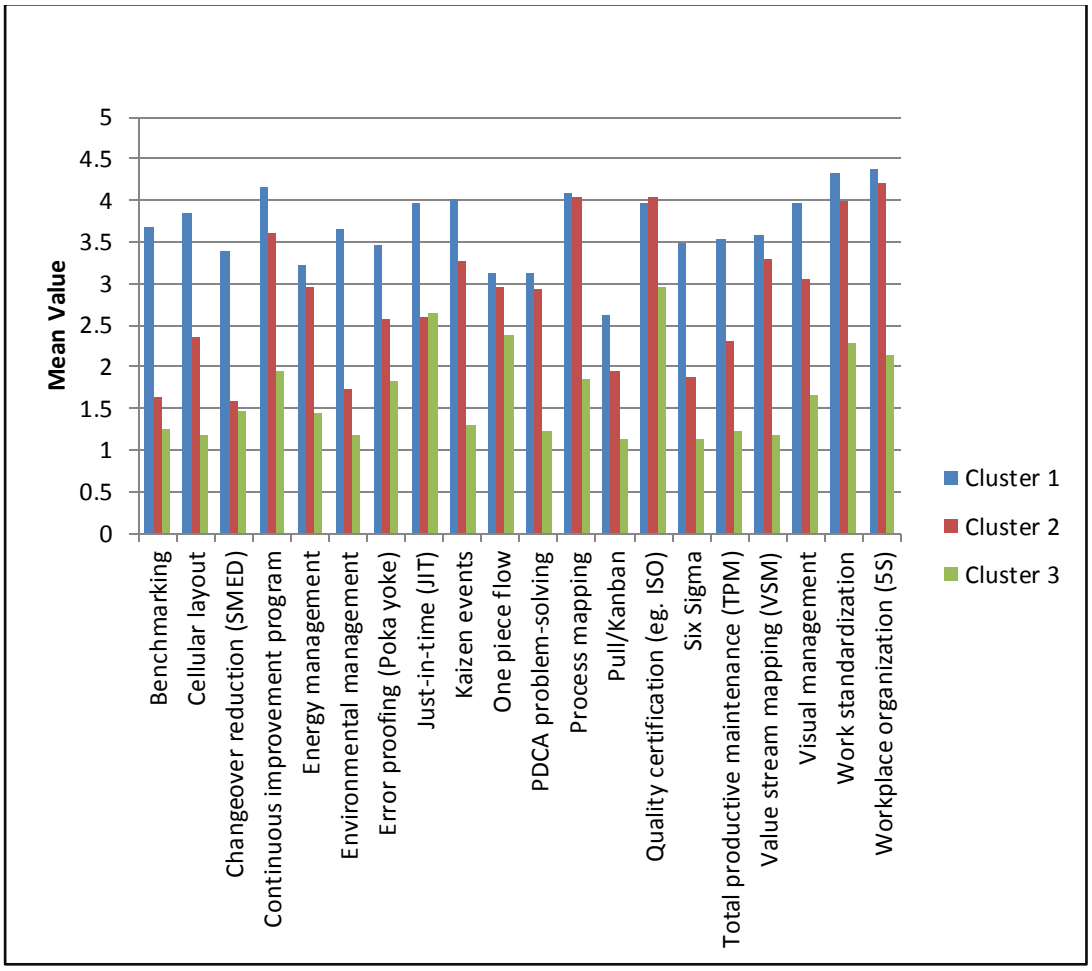

Figure 4.26: Cluster Analysis of Lean Tools

Table 4.12 shows the person correlation between lean tools in SMEs. All the tools have moderately positive Pearson correlation values which shows that all the tools are positively correlated with each other that means the implementation of one lean tool influences the implementation of other lean tools. For example the Pearson correlation value between Value stream mapping (VSM) and Continuous improvement program is 0.736 which means both of these tools have very strong positive correlation and if a company is implementing value stream mapping tools in its systems then it will also focuses on continuous improvement platform for its processes.

Table 4.12: Correlation between lean Tools

Correlation	Kaizen events	Quality certification (e.g. ISO)	Work standardization	Visual management	Value stream mapping (VSM)	Error proofing (Poka yoke)	Cellular layout	Total productive maintenance (TPM)	Continuous improvement program	One piece flow	Workplace organization (5S)	Energy management	Changeover reduction (SMED)	Pull/Kanban	PDCA problem-solving	Process mapping	Benchmarking	Six Sigma
Kaizen events	1	.37**	.72**	.80**	.78**	.69**	.67**	.73**	.61**	.43**	.83**	.81**	.47**	.58**	.73**	.77**	.60**	.74**
Quality certification (e.g. ISO)		1	.66**	.35**	.42**	.57**	.24**	.23**	.58**	.50**	.44**	.23**	.41**	.35**	.39**	.39**	.15	.14
Work standardization			1	.76**	.79**	.67**	.68**	.73**	.84**	.43**	.80**	.56**	.55**	.54**	.55**	.77**	.58**	.58**
Visual management				1	.80**	.79**	.73**	.76**	.70**	.47**	.79**	.74**	.60**	.62**	.68**	.85**	.70**	.77**
Value stream mapping (VSM)					1	.65**	.72**	.74**	.73**	.39**	.87**	.71**	.49**	.63**	.72**	.82**	.52**	.64**
Error proofing (Poka yoke)						1	.57**	.55**	.63**	.76**	.64**	.65**	.58**	.49**	.62**	.65**	.50**	.68**
Cellular layout							1	.90**	.76**	.25**	.69**	.54**	.66**	.62**	.44**	.68**	.82**	.77**
Total productive maintenance (TPM)								1	.75**	.22*	.68**	.57**	.70**	.63**	.46**	.70**	.86**	.81**
Continuous improvement program									1	.38**	.72**	.43**	.56**	.62**	.44**	.70**	.61**	.53**
One piece flow										1	.40**	.51**	.27**	.25**	.50**	.47**	.12	.40**
Workplace organization (5S)											1	.73**	.42**	.61**	.77**	.85**	.54**	.56**
Energy management												1	.37**	.61**	.81**	.78**	.46**	.72**
Changeover reduction (SMED)													1	.70**	.33**	.43**	.74**	.62**
Pull/Kanban														1	.56**	.64**	.60**	.51**
PDCA problem-solving															1	.79**	.35**	.49**
Process mapping																1	.53**	.64**
Benchmarking																	1	.76**
Six Sigma																		1

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

4.3 Critical Success factors of Lean implementation in SMEs in Pakistan

The respondent companies were asked to prioritize the critical success factors of lean implementation on the scale of 1 to 5 where 5 being the strongly agree and 1 as strongly disagree. The Figure 4.27 shows the mean value of 13 critical success factors of lean implementation in the context of small medium enterprises in Pakistan.

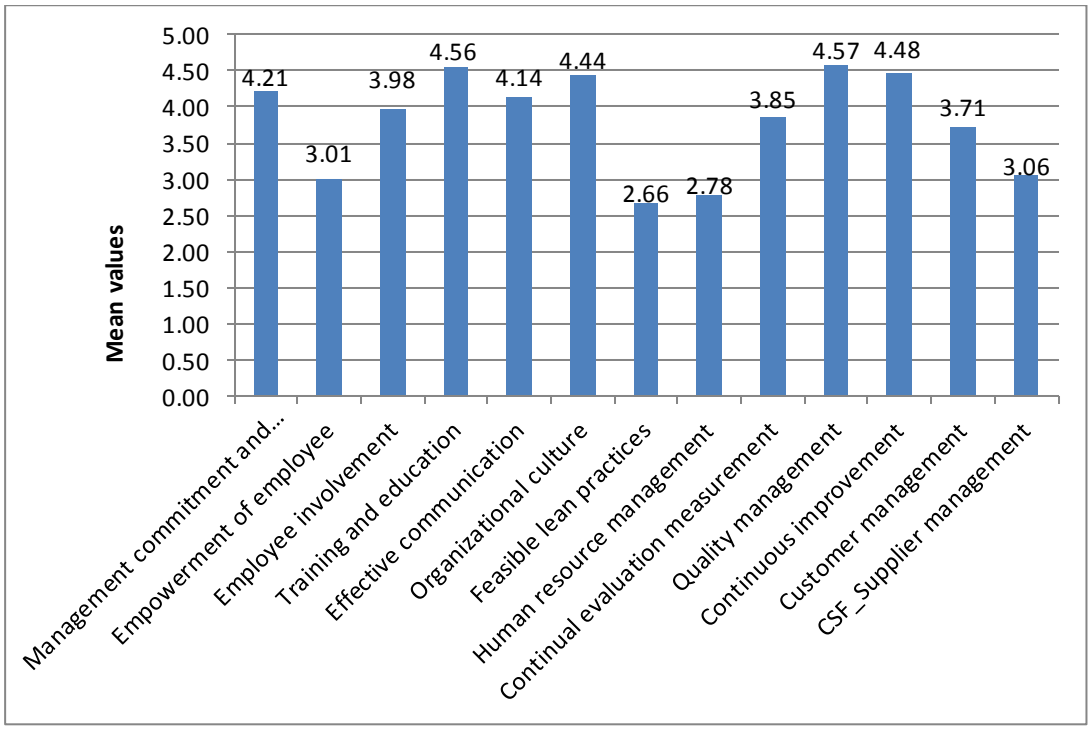

Figure 4.27: Critical Success Factors

By ordering from the largest mean value to the smallest, the rank of 13 critical success factors is shown in the Table 4.13. The interesting findings are that quality management, training and education, continuous improvement and organizational culture with mean values of 4.57, 4.56, 4.48 and 4.44 respectively, are the most common critical success factors for lean practices in SMEs.

Table 4.13: Critical Success Factors of Lean implementation

Critical Success Factors	Rank	Mean	Std. Deviation	Variance
Quality management	1	4.57	.587	.344
Training and education	2	4.56	.641	.410
Continuous improvement	3	4.48	.727	.528
Organizational culture	4	4.44	.829	.687
Management commitment and leadership	5	4.21	.602	.362
Effective communication	6	4.14	.546	.298
Employee involvement	7	3.98	.941	.886
Continual evaluation measurement	8	3.85	.634	.402
Customer management	9	3.71	.696	.484
Supplier management	10	3.06	.810	.655
Empowerment of employee	11	3.01	.770	.593
Human resource management	12	2.78	.812	.660
Feasible lean practices	13	2.66	.661	.437

4.4 Barriers of Lean implementation in SMEs

Companies were also asked to identify the barriers and hurdles they are facing while practicing and implementing lean in their processes. A list of 16 barriers was identified and respondent companies were asked to grade then on a scale of 1 to 5. To get the clear picture of barriers faced by companies, same cluster analysis was performed which was "highly lean companies (Cluster-1), somewhat lean companies (Cluster-2) and not at all Lean companies (Cluster-3). The results are given in the Table 4.14.

Change process, Resistance to change, Training, Creating multifunctional teams and Collaborations among functions are most rated barriers in cluster 1 companies. Adoption of lean practices faces resistance from employees, so even the highly lean companies are also facing this problem. Lean implementation needs training and education of the employees and these companies are facing his problem. The least rated barriers these companies are facing include Finance, Reducing WIP, Supplier collaboration and Lack of skilled employee.

Cluster-2 represents companies which have moderately implemented lean practices in their systems and the most important barriers they are facing are almost same like highly lean companies which are, Resistance to change, Change process, Product variety, Cultural problems and Training. These findings shows that lean implementation needs a lot of changes in the companies way of operations and that is

the reason the companies are facing the resistance to change as the most important obstacle. Hence, change process and knowledge and training are the most important obstacles companies must have to overcome for successful lean implementation.

The companies which are beginners in lean implementation are represented by cluster-3 and as obvious, Resistance is to change is also an important barrier in this group as well. Finances, Training, and Product Variety are other mostly observed obstacles in this group.

As these companies are in early stage of adoption of lean practices so they are facing financial issues to support these new practices. To get successful in lean implementation the companies have to overcome these barriers.

Table 4.14: Barriers of lean implementation based on Cluster Analysis

Cluster-1 (n=52)		**Cluster-2 (n=33)**		**Cluster-3 (n=39)**	
Barriers	**Mean**	**Barriers**	**Mean**	**Barriers**	**Mean**
Change process	4.23	Resistance to change	4.70	Resistance to change	4.77
Resistance to change	4.06	Change process	4.61	Finance	4.41
Training	4.06	Product variety	4.33	Training	4.41
Creating multifunctional teams	3.77	Cultural problems	4.18	Change process	4.28
Collaborations among functions	3.67	Training	4.09	Product variety	4.21
Cultural problems	3.65	Supplier collaboration	3.79	lack of time	4.10
JIT delivery	3.62	Finance	3.58	Lack of skilled employee	4.03
Product variety	3.54	lack of time	3.48	Cultural problems	4.00
lack of time	3.40	JIT delivery	3.39	Management support	3.97
JIT purchase	3.40	JIT purchase	3.24	Supplier collaboration	3.72
Management support	3.37	Management support	3.21	Late profit	3.38
Late profit	3.27	Reducing WIP	3.06	JIT delivery	3.10
Finance	3.23	Creating multifunctional teams	2.97	Collaborations among functions	3.08

Table 4.14 (Continued): Barriers of lean implementation based on Cluster Analysis

Cluster-1 (n=52)		Cluster-2 (n=33)		Cluster-3 (n=39)	
Barriers	**Mean**	**Barriers**	**Mean**	**Barriers**	**Mean**
Reducing WIP	3.23	Collaborations among functions	2.94	JIT purchase	2.95
Supplier collaboration	3.06	Late profit	2.79	Reducing WIP	2.87
Lack of skilled employee	3.04	Lack of skilled employee	2.73	Creating multifunctional teams	2.72

4.4.1 Analysis of barriers of lean based on number of years of lean practices

The Box and whisker plots are used to individually identify and analyze the barriers faced by Small Medium Enterprises based on the numbers of years of lean practices.

One of the major barriers which companies have identified is the change process from traditional ways of working to the new lean ways. As the Figure-4.28 shows that the companies faces this barrier no matter how much lean experience they gain. It is always difficult to convert to new ways of production by changing the traditional ways of working.

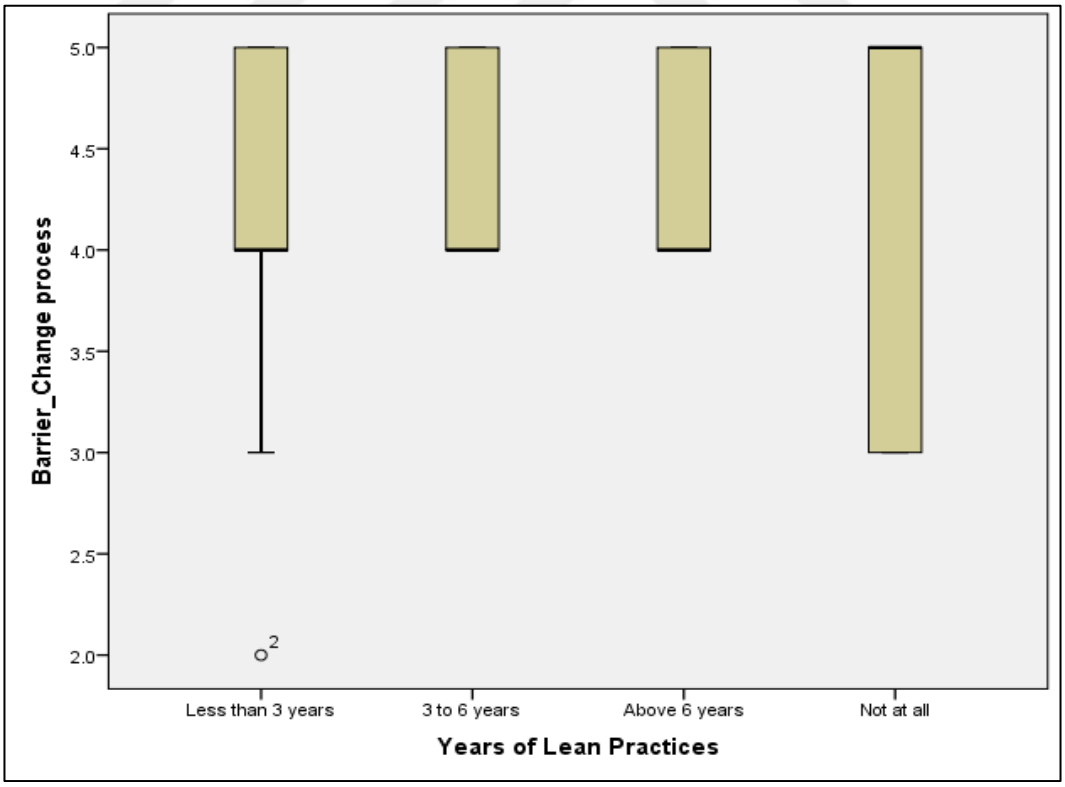

Figure 4.28: Change process barrier based on lean experience

The successful lean implementation depends on the support and commitment from the top management and most of the companies which are trying to convert to lean

practices face this barrier as of the major barrier. The box and whisker plot (Figure-4.29) shows that the companies which are in their stages of lean adoption or which do not have lean experience at all faces this barrier more.

But as the time span increasers in terms of lean experience the companies face this barrier less because with the time, the management becomes more involved in the lean practices keeping in view the advantages gained by these practices.

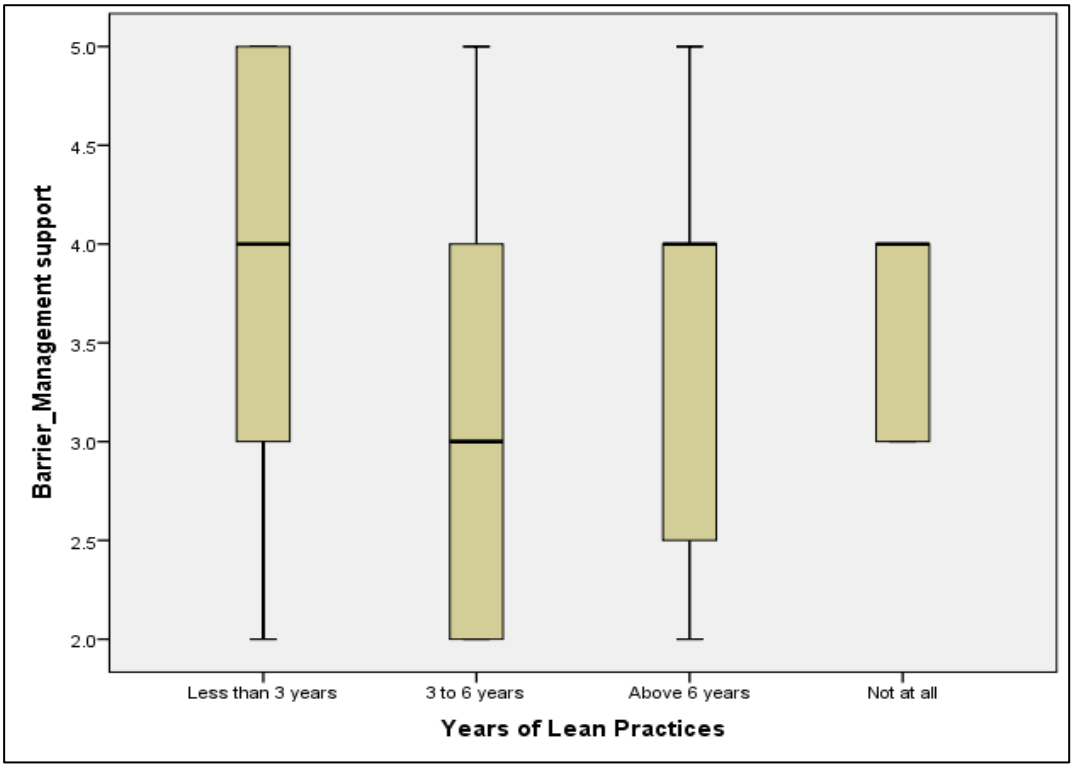

Figure 4.29: Management support barrier based on lean experience

Same is in the case of finances which are mostly faced by the companies having no experience of lean at all of who are in early ears of lean adoption. Since it is difficult to convince the management to invest in the new ways of working at an early stage but with the passage of time, the companies having more experience of lean faces this barrier less (Figure-4.30).

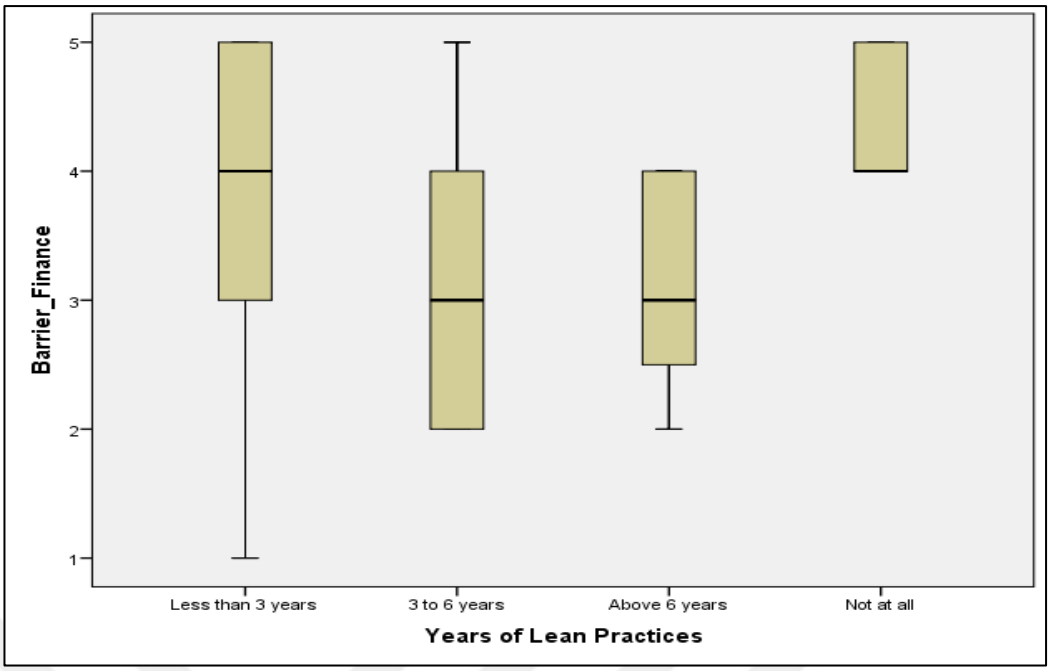

Figure 4.30: Finances barrier based on lean experience

Figure 4.31 shows the box and whisker plot for resistance to change barrier based on the number of years of lean practices. It is very clear that all the companies which have no experience of lean at all have graded this barrier at the highest level. Also the companies which are in the early stages of lean implementation are facing this barrier more. But this barrier is always faced by the companies no matter how much lean experience they have attained.

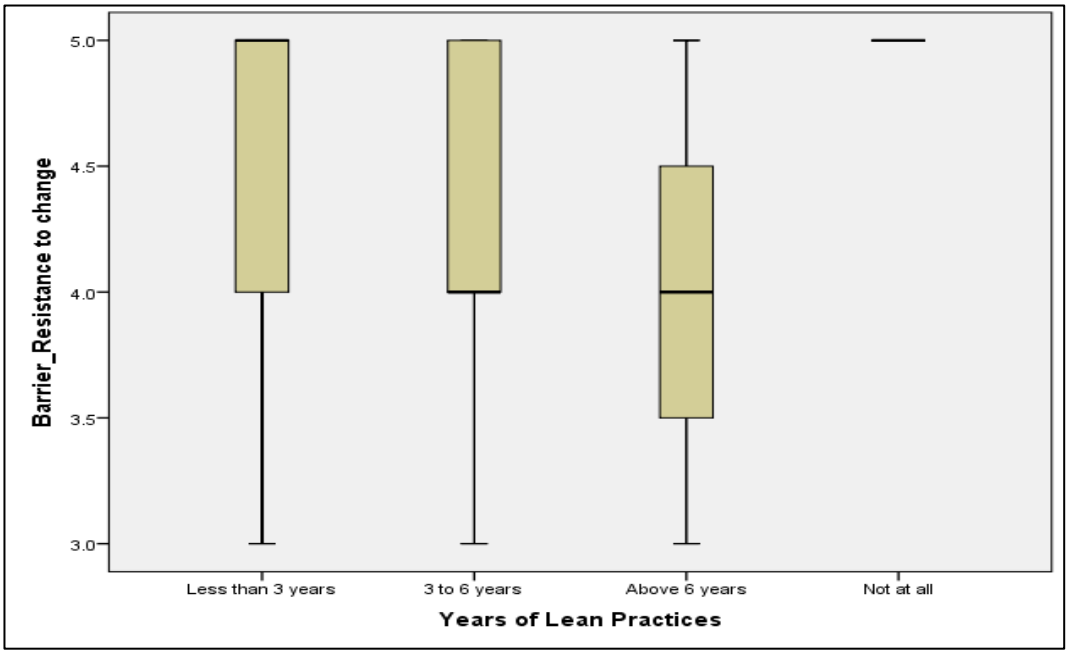

Figure 4.31: Resistance to change barrier based on lean experience

The box and whisker plots for other barriers were also drawn i.e. Supplier Collaboration (Figure-4.32), Training (Figure-4.33), Lack of time (Figure-4.34), Product Variety (Figure-4.35), Lack of skilled employee (Figure-4.36), Late Profit (Figure-4.37), Reducing WIP (Figure-4.38), JIT delivery (Figure-4.39), JIT purchase (Figure-4.40). These plots shows that mostly the barriers are faced by the SMEs which have not implemented lean at all, or which are in early stages of lean adoption, and as soon the companies getting lean experiences these barriers also fades with time.

The lean barriers were also plotted based on the company sector. Different sectors of the companies have highlighted different levels of lean barriers. Food and drinks, warehousing and consumer services have highest the highest level of lean barriers faced by these companies. Half of automobile SMEs have faced high lean barriers and half of these have highlighted low level of lean barriers.

The box and Whisker plots used in the above section are just for the information purpose and to get the better picture of the results and analysis.

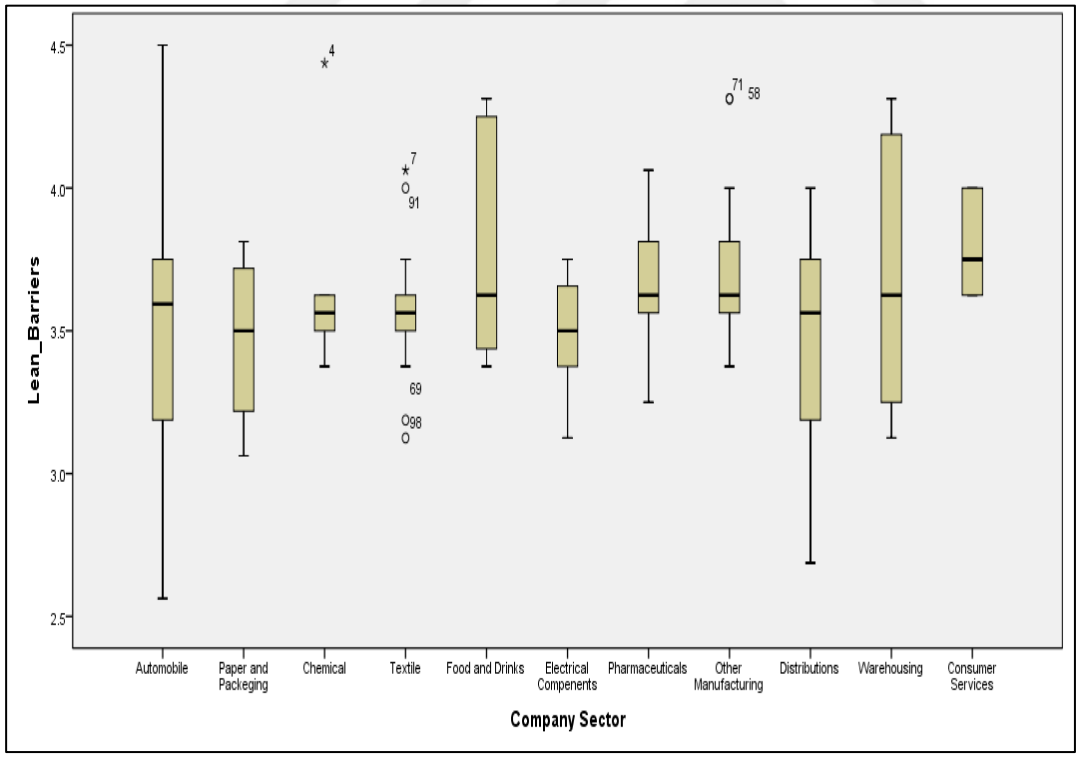

Figure 4.42: Lean barrier based on company sector

4.5 Benefits of Lean implementation in SMEs

Another aspect of our survey was to identify the benefits achieved through lean implementation in SMEs. 13 benefits were listed in our survey questionnaire and the respondent companies were asked to identify the benefits which they have achieved through Lean practices. The summarized result is shown in the Table 4.15. All the benefits have a good mean value which shows that Lean practices surely have a positive impact on the benefits which SMEs achieve.

Among the benefits, reduced waste, improved profitability, increased productivity and efficiency are the most achieved benefits from Lean practices, which mean lean practices have a positive relationship with waste reduction, profit increase, production improvement and customer satisfaction. On the other hand product development was the least benefit which company faced using lean practices. The reason of it could be that most of the SMEs do their product development using outsourcing and there is still a need to improve product development systems in SMEs.

Table 4.15: Benefits of Lean implementation

Benefits	Rank	Mean	Std. Deviation	Variance
Reduced waste	1	4.07	.788	.621
Improved profitability	2	4.04	.617	.380
Increase in Productivity and Efficiency	3	3.99	.821	.675
Increased customer satisfaction	4	3.90	.932	.869
Reduced manufacturing/inventory cost	5	3.85	.899	.808
Improvement in Product/Service quality	6	3.81	.671	.450
Achieving a more competitive position in the market	7	3.31	.734	.539
Increased Just-in-time Service	8	3.20	.826	.683
Reduced Logistics cost	9	2.85	.823	.678
Decline in Purchasing Cost	10	2.75	.750	.563
Improved ability to handle unexpected events	11	2.71	.684	.468
Culture change within the organization	12	2.59	.721	.521
Improved Product Development	13	2.56	.701	.492

4.6 Factor Analysis of Critical Success Factors

A factor analysis using SPSS was applied. The analysis method used for the extraction of factor was “Principle component analysis” with “Varimax” for the

rotation. Items with factor loadings above 0.50 were considered to determine item representation of a single factor.

The data set had Kaiser-Meyer-Olkin Measure of Sampling with significance level < 0.000. The initial eigenvalues, extraction sum of squared loadings and rotation sums of squared loadings are shown in the Table 4.16.

4.6.1 Extraction of Factors

Four numbers of components are extracted based on the Eigen value greater than 1. The four components show a total of 70.67 percent of variation in the data.

Table 4.16: Extraction of factors

Comp	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	3.76	28.99	28.99	3.76	28.99	28.99	2.90	22.35	22.35
2	2.40	18.46	47.45	2.40	18.46	47.45	2.62	20.17	42.53
3	1.81	13.95	61.41	1.81	13.95	61.41	2.06	15.87	58.40
4	1.20	9.26	70.67	1.20	9.26	70.67	1.59	12.27	70.67
5	.931	7.161	77.841						
6	.732	5.633	83.473						
7	.637	4.897	88.370						
8	.519	3.991	92.361						
9	.330	2.540	94.901						
10	.283	2.179	97.080						
11	.177	1.358	98.438						
12	.130	.998	99.436						
13	.073	.564	100.000						

4.6.2 Scree plot

How many number of factors should be extracted was based on the Eigen value greater than 1. Scree plot (Figure-4.43) shows the eigenvalues plotted against factor number so that a sharp turn in the curve can be used to decide for number of components to be used.

Though the decision was made earlier that the components with eigenvalues >= 1 will be considered. Similarly the variables with loading >= 0.50 were considered for inclusion in components.

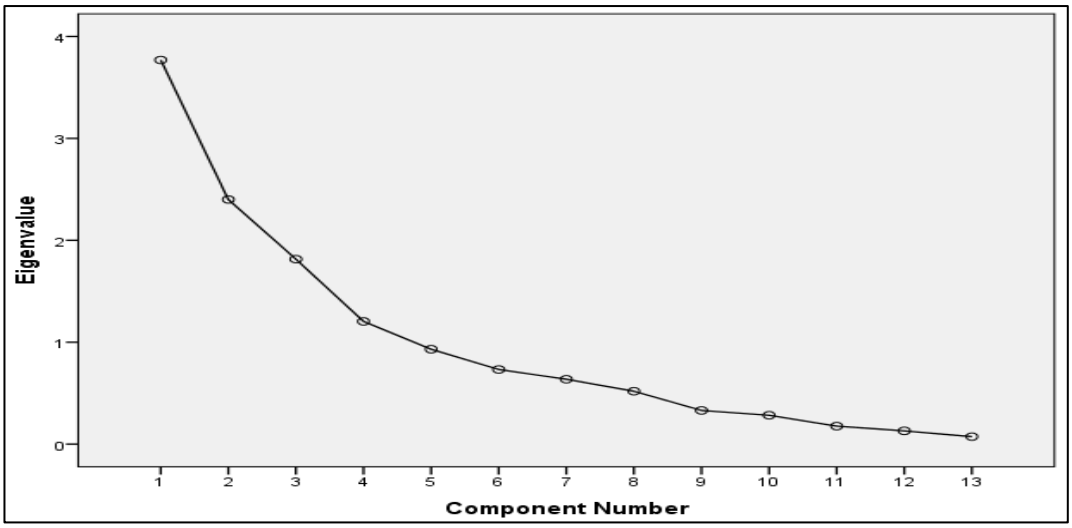

Figure 4.43: Scree Plot for Factor Analysis

4.6.3 Rotated Component Matrix

The rotated components matrix given in Table-4.17 shows the five components with the subsequent factors representations in them as following:

Table 4.17: Rotated component Matrix

Item	Component			
	1	2	3	4
Supplier management	0.79			
Human resource management	0.77			
Continual evaluation measurement	0.73			
Empowerment of employee	0.55			
Training and education		0.83		
Organizational culture		0.80		
Employee involvement		0.71		
Management commitment and leadership		0.67		
Quality management			0.80	
Continuous improvement			0.75	
Feasible lean practices			0.65	
Effective communication				0.77
Customer management				0.76
Extraction Method: Principal Component Analysis. Rotation Method: Varimax with Kaiser Normalization. Rotation converged in 11 iterations.				

4.6.4 Calculating Component Scores

The component score are calculated based on their factor loadings in that component by forming the equations given in Table 4.18.

Table 4.18: Component score calculation using factor loadings

Component	Factors Involved in order of Importance	Equation to calculate component score with loading coefficients
Compoenent-1	Supplier management (SM) Human resource management (HRM) Continual evaluation measurement (CE) Empowerment of employee (EE)	= 0.79*SM + 0.77*HRM + 0.73*CE + 0.55*EE
Compoenent-2	Training and education (TE) Organizational culture (OC) Employee involvement (EI) Management commitment and leadership (MC)	= 0.83*TE + 0.80*CO + 0.71*EI + 0.67*MC
Compoenent-3	Quality management (QM) Continuous improvement (CI) Feasible lean practices (FL)	= 0.80*QM + 0.75*CI + 0.65*FL
Compoenent-4	Effective communication (EC) Customer management (CM)	= 0.77*EC + 0.76*CM

4.6.5 Descriptive Measures of Components

The average score for the component-1 with 4 factors was 9.02±1.64 with maximum value of 13.47. Similarly the average scores were 12.39±1.72, 8.74±0.85 and 6.00±0.77 for the component-2, component-3 and component-4 with 44, 3 and 2 factors respectively (Table-4.19).

Table 4.19: Descriptive Measures of Components

	Component-1	Component-2	Component-3	Component-4
Mean	9.02	12.39	8.74	6.00
Std. Deviation	1.64	1.72	0.85	0.77
Minimum	4.12	8.54	6.60	3.83
Maximum	13.47	14.35	10.35	7.65

4.6.6 Comparison of Components based on Company type

The average scores for component-1 was highest for the small manufacturing companies, component-2 and component-3 for medium manufacturing and the component-4 had highest average score for Micro Companies. (Table 4.20)

Table 4.20: Descriptive measures based on Company Type

	Company Type											
	Micro Companies (<10)				Small Companies (10-49)				Medium Companies (50-249)			
	Compoenet-1	Compoenet-2	Compoenet-3	Compoenet-4	Compoenet-1	Compoenet-2	Compoenet-3	Compoenet-4	Compoenet-1	Compoenet-2	Compoenet-3	Compoenet-4
Mean	7.37	11.61	8.44	**6.86**	**9.17**	12.27	8.68	5.99	9.03	**12.52**	**8.81**	6.08
SD	2.38	2.48	1.21	1.07	1.63	1.78	0.87	0.76	1.38	1.61	0.80	0.75
Min	4.12	8.54	6.60	5.00	4.12	8.61	6.60	4.59	4.12	8.61	6.60	4.59
Max	9.98	14.35	10.35	8.00	13.47	14.35	9.70	7.65	10.99	14.35	10.35	7.65

4.6.7 Comparison of components based on no of years of lean practices

Components are compared based on the no of years of lean practices. The Table 4.21 summarizes the results which shows that the companies having less than 3 years of experience gives more importance to the component-2 which includes Training and education, Organizational culture, Employee involvement and Management commitment and leadership, Which shows that early adoption of lean becomes difficult to start because of the old conservative methods of working and the resistance to change therefore to start a successful implementation of lean, it is necessary to change the culture of the organization first. It can be done by giving them knowledge and knowhow of the system at early stage so that the employees in the company take the responsibility of making lean practices successful to get the best befits from Lean practices. On the other hand, the companies having three to six years of lean experience have higher score for component-3 which is Quality management, Continuous improvement and Feasible lean practices. Component-1, Supplier management, Human resource management, continual evaluation measurement and Empowerment of employee, has higher score for companies having more than 6 years of experience.

Table 4.21: Descriptive measures based on No of years of lean practices

	No of years of Lean practices															
	Less than 3 Years				3-6 Years				Above 6 Years				Not at all			
	Compoenet-1	Compoenet-2	Compoenet-3	Compoenet-4	Compoenet-1	Compoenet-2	Compoenet-3	Compoenet-4	Compoenet-1	Compoenet-2	Compoenet-3	Compoenet-4	Compoenet-1	Compoenet-2	Compoenet-3	Compoenet-4
Mean	8.90	12.8	8.7	6.0	9.2	12.5	9.1	6.3	10.2	12.3	8.9	5.3	8.23	12.1	8.4	6.4
SD	1.61	1.5	0.8	0.8	1.68	1.5	0.8	0.7	1.69	1.7	0.7	0.5	1.12	2.3	1.1	0.6
Min	4.12	10.0	6.6	3.8	4.12	10.0	8.2	4.6	7.2	8.5	7.5	4.6	4.12	8.6	6.6	5.4
Max	11.4	14.4	10.4	7.7	10.8	14.4	10.4	7.7	13.5	14.4	10.4	6.1	9.25	13.8	9.1	7.7

5. CONCLUSION AND FUTURE RECOMMENDATIONS

5.1 Conclusion

The main purpose of any economic investment is to get profit at the end. Investors and business holders invest in business or shares for wealth maximization. As the investment in large companies bears complexities, which influences investors to invest in small or medium enterprises which converts into medium or large companies at the later stage with profitability. The competition in global market is forcing Small medium enterprises to focus on new production methodologies to survive in the market. One of those production methodologies is lean manufacturing. The literature has highlighted a number of research gaps related to the Lean practices and impacts on Small and Medium size enterprises. Previous research has been performed on the Lean implementation in large companies while a little research has been done on its application in small and medium enterprises. The purpose of this research is to examine and enhance the understanding of lean practices, benefits, barriers and critical success factors of lean in SMEs of Pakistan.

A questionnaire methodology was used to collect the data related to lean implementation in Pakistani SMEs. 300 companies were contacted and 124 of them participated in the survey which makes the response rate of 42%. Manufacturing and service, both type of companies participated in the survey which includes, automobile, metal goods, paper and packaging, chemicals, textiles, food and drinks, electrical components pharmaceuticals, distributions, warehousing and consumer services.

The results shows that more than fifty percent of the companies have implemented lean practices for less than three years while 11 percent of the respondent companies have not implemented lean at all, which shows that SMEs in Pakistan are still at an early stage of lean adoption. In terms of Lean tools, the most common implemented tools are Quality certification (e.g. ISO), Workplace organization (5S), Work standardization and Process mapping. To get better understanding of lean implemented tools in SMEs, a cluster analysis was performed which divided the

respondent companies into three different cluster named as, Highly Lean companies (cluster-1), Somewhat Lean Companies (Cluster-2) and Not at all Lean companies.

Workplace organization, work standardization, continuous improvement program, process mapping and kaizen events are the most commonly implemented lean tools in highly lean companies. These results show that the lean companies focus on the overall effectiveness and efficiency of the systems. On the other hand, for somewhat lean companies, the most common highly implemented tools in this category are Workplace organization (5S), Quality certification (e.g. ISO), Process mapping and Work standardization, as the early adopters start practicing lean tools which are easy to start and implement. Same is in the case of Not at all Lean companies which have Quality certification (e.g. ISO), Just-in-time (JIT), One piece flow, Work standardization, Workplace organization (5S) as highly implemented lean tools in these companies as these are the tools which are easy to adopt and implement. On the other hand the least implemented lean tools are pull/Kanban and Six Sigma because these are the tools which need detailed study of the system and they require continuous effort and financial stability to get the benefits from these tools.

A list of lean benefits was also included in the research. Waste reduction, Increased profit and productivity, improved efficiency were top benefits indicated by the respondent companies which means lean practices have a positive relationship with waste reduction, profit increase, production improvement and customer satisfaction. On the other hand product development was the least benefit which company faced using lean practices. The reason of it could be that most of the SMEs do their product development using outsourcing and there is still a need to improve product development systems in SMEs.

The respondent companies were also asked to highlight the barriers they are facing for lean implementation. A cluster analysis was performed to analyze the results using the same three clusters named as, highly lean companies, somewhat lean companies and Not at all Lean companies. Among all three clusters, resistance to change was the highest rated barrier. These findings shows that lean implementation needs a lot of changes in the companies way of operations and that is the reason the companies are facing the resistance to change as the most important obstacle. Among other important obstacle was training and education, which shows that the employees need to train to understand and implement new methodologies to get successful lean

implementation. For the cluster-3 (not at all Lean companies) one of the highest rated obstacles for lean implementation is Finances, as these companies are in early stage of adoption of lean practices so they are facing financial issues to support these new practices.

A list of critical success factors of lean implementation derived from literature and companies were asked to rate those factors on a scale of 1 to 5. Quality management, training and education, continuous improvement and organizational culture are the most common critical success factors for lean practices in SMEs.

A factor analysis was performed to get better understanding of Critical success factors of lean implementation. 13 factors were reduced to three major components which show a total of 71 percent of variability in the data. Componenet-1 comprises of following factors: Supplier management, Human resource management, continual evaluation measurement and Empowerment of employee. Training and education, Organizational culture, Employee involvement and Management commitment and leadership are presented by Componenet-2. Quality management, Continuous improvement and Feasible lean practices are parts of Component-3, whereas, Effective communication and Customer management comes under Compoenent-4. The components are compared on the basis of company types i.e. Micro Companies (<10), Small Companies (10-49), Medium Companies (50-249). Small manufacturing companies have highest score for componenet-1, whereas component-2 and component-3 for medium manufacturing and the component-4 had highest average score for Micro Companies. The components scores were also compared on the basis of no of years of lean practices. Component-2 which includes Training and education, Organizational culture, Employee involvement and Management commitment and leadership has high score for the companies having less than 3 years of experience, Which shows that early adoption of lean becomes difficult to start because of the old conservative methods of working and the resistance to change. On the other hand, the companies having three to six years of lean experience have higher score for component-3 which is Quality management, Continuous improvement and Feasible lean practices. Component-1, Supplier management, Human resource management, continual evaluation measurement and Empowerment of employee, has higher score for companies having more than 6 years of experience. The output of this research is summarized in the Figure-5.1.

Lean implementation needs to start from adopting basic lean tools. And while implementing lean in the companies there will be lots of barriers faced by companies which will show a negative influence on the lean implementation but those barriers can be overcome by working on some critical success factors which will have positive affect on the implementation of lean. The successful lean implementation will bring benefits to the SMEs and will affect different aspects of an organizations performance, in terms of Operations performance and business performance.

5.2 Limitations and Future Research

This research was based on the survey of lean implementation in Pakistani SMEs. The results show that Pakistani SMEs are still in early stages of lean implementation and many of the SMEs have not implemented lean at all. This study is based on a small sample size, which cannot highlight the overall picture of the SMEs in Pakistan. The future researchers can be based on a large sample size and also it can include case studies to get detailed and better understating of lean practices in SMEs. Also, more time, more types of companies from different sectors should include in the research. In future researcher can determine lean implementation status in telecommunication sector, as Pakistan have greater amount of SME's. Lean is more implemented in telecommunication sector. The financial benefits achieved using lean practices can also be a part of future research using SMEs return on investment and productivity improvement figures.

This research has highlighted that resistance to change and cultural barriers are among the mostly faced obstacles in SMEs for lean implementation, the future research can be based on the detailed study of cultural change parameters in different sectors of Pakistani industries to highlight what type of cultural change is required to embed the lean approach in a system/process. In future research supplier and customer training to implement successful lean manufacturing can be performed by considering the parameters used for training from literature review.

Moreover this research analysis was entirely based on Pakistani SMEs and it cannot be generalized for other countries as well. The future researches can also be performed on the comparison of lean practices in different countries.

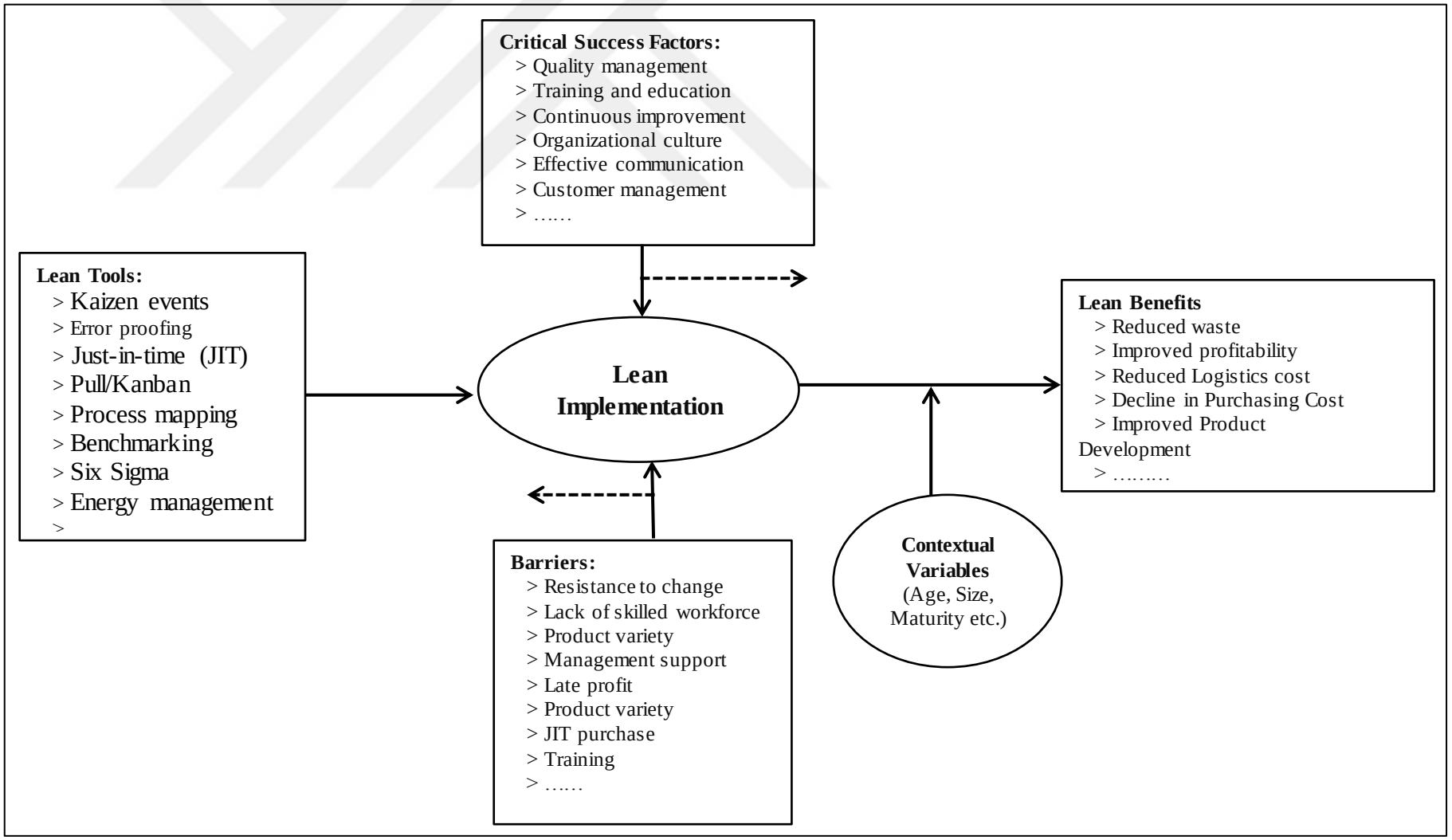

Figure-5.1: Successful Lean Implementation

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APPENDICES

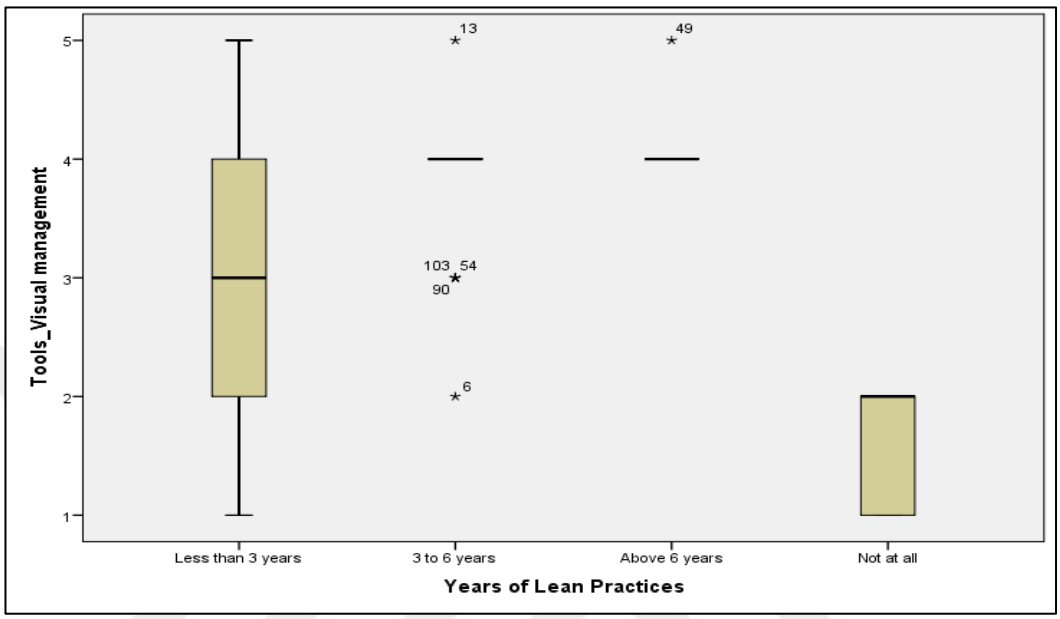

Figure 4.6: Visual Management based on Lean experience

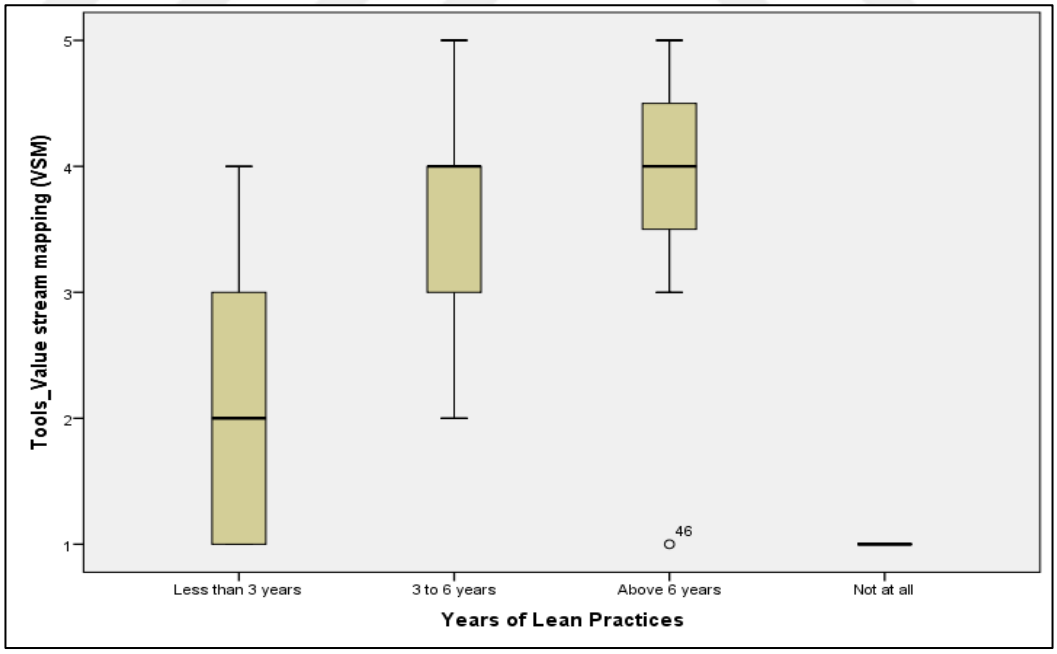

Figure 4.7: Value Stream Mapping based on Lean experience

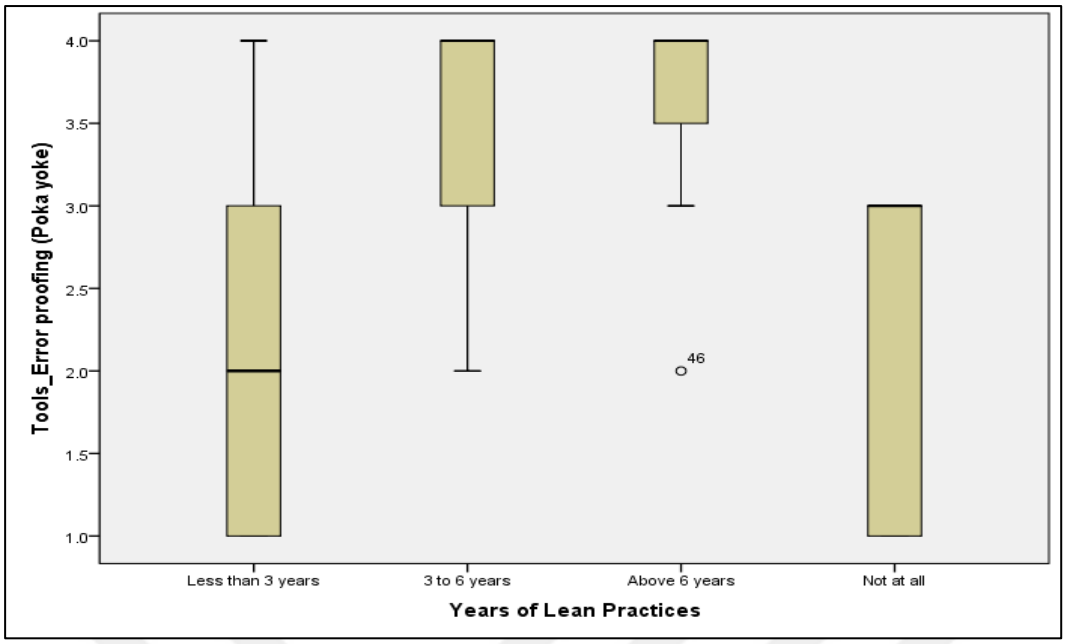

Figure 4.8: Error Proofing based on Lean experience

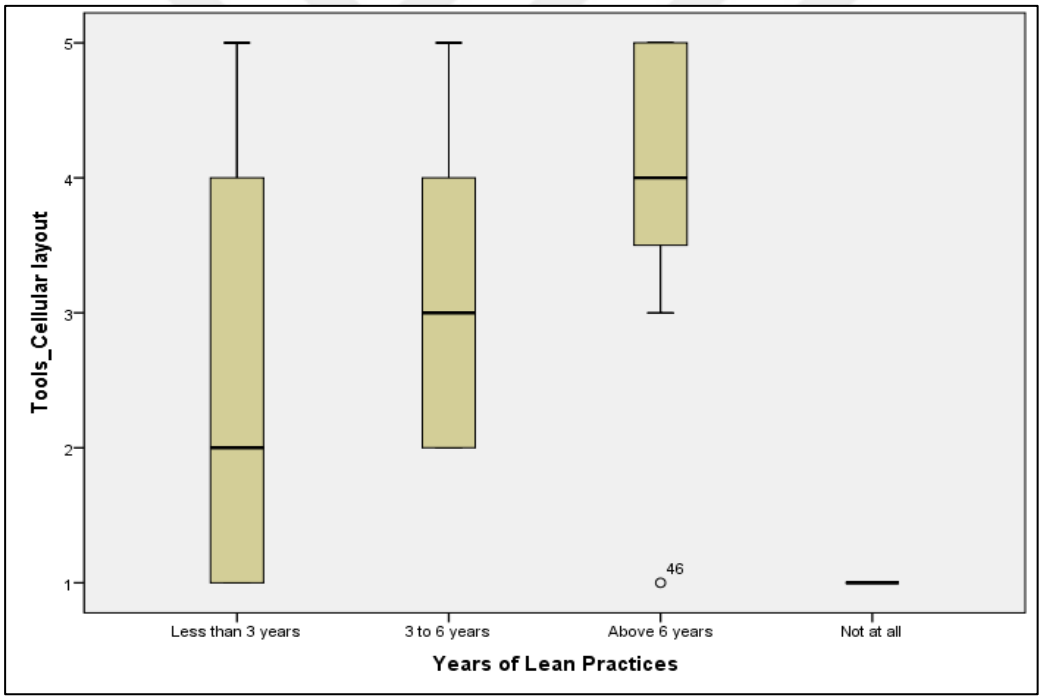

Figure 4.9: Cellular Layout based on Lean experience

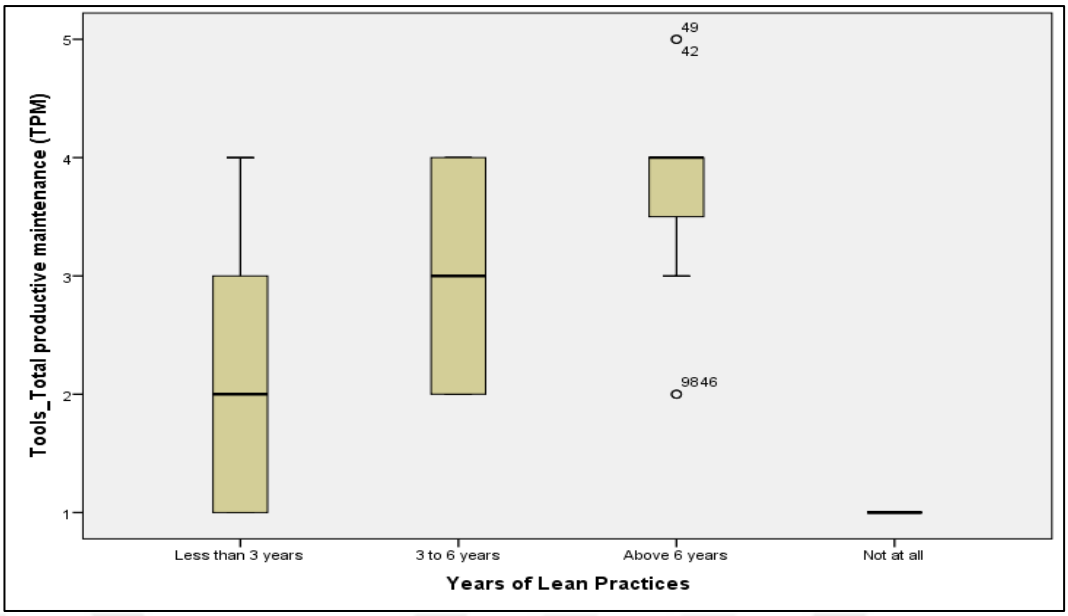

Figure 4.10: Productive Maintenance based on Lean experience

Figure 4.11: Continuous Improvement based on Lean experience

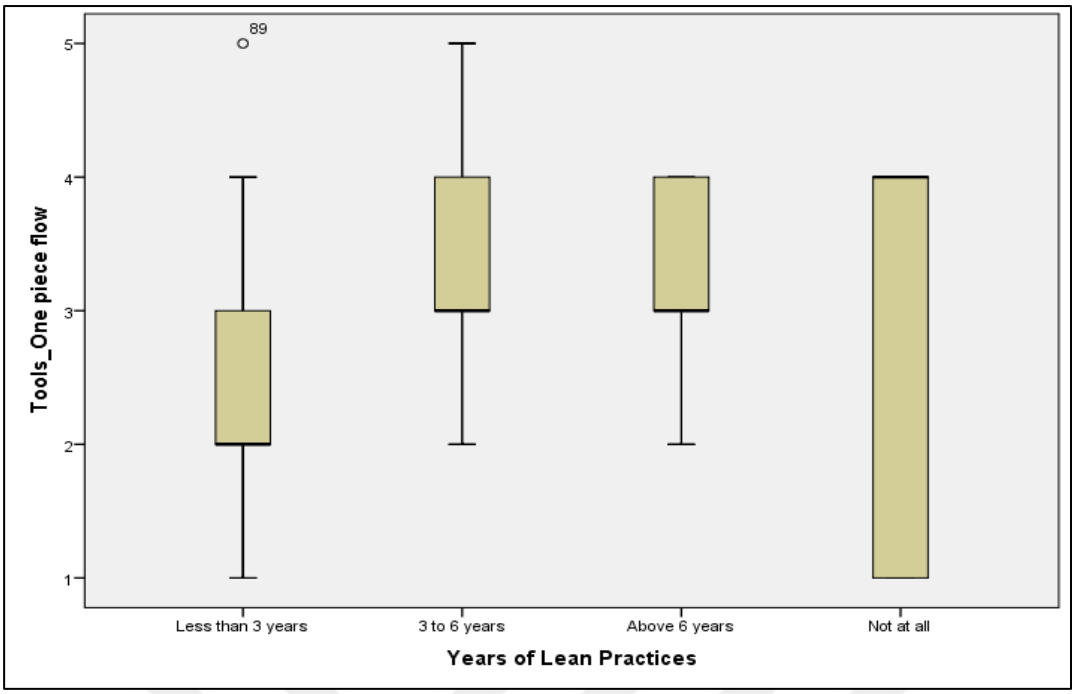

Figure 4.12: One piece Flow based on Lean experience

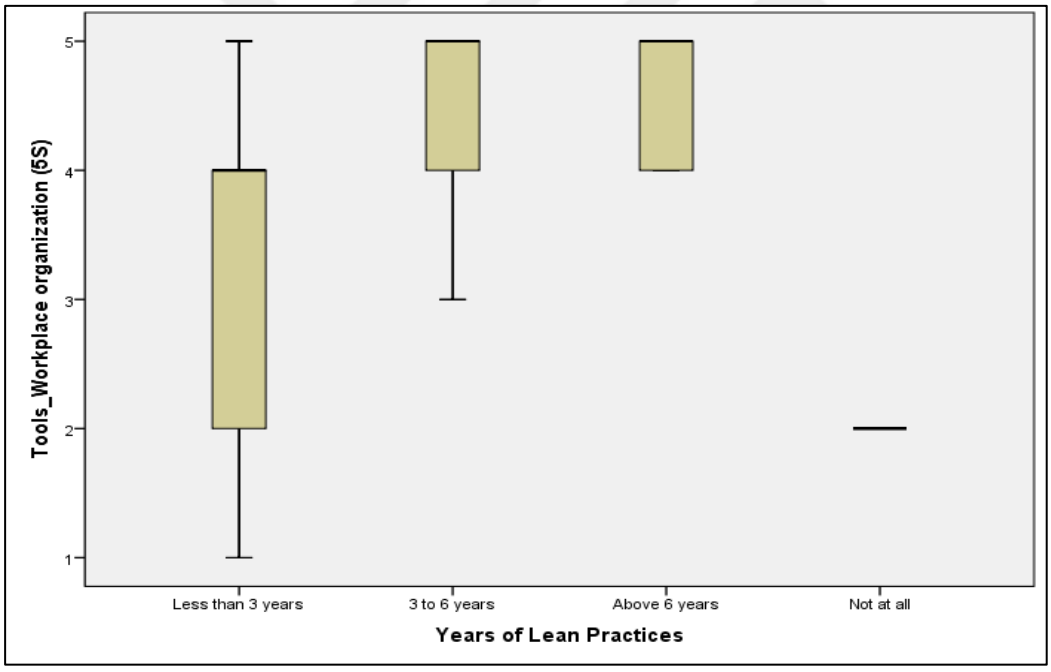

Figure 4.13: Workplace organization based on Lean experience

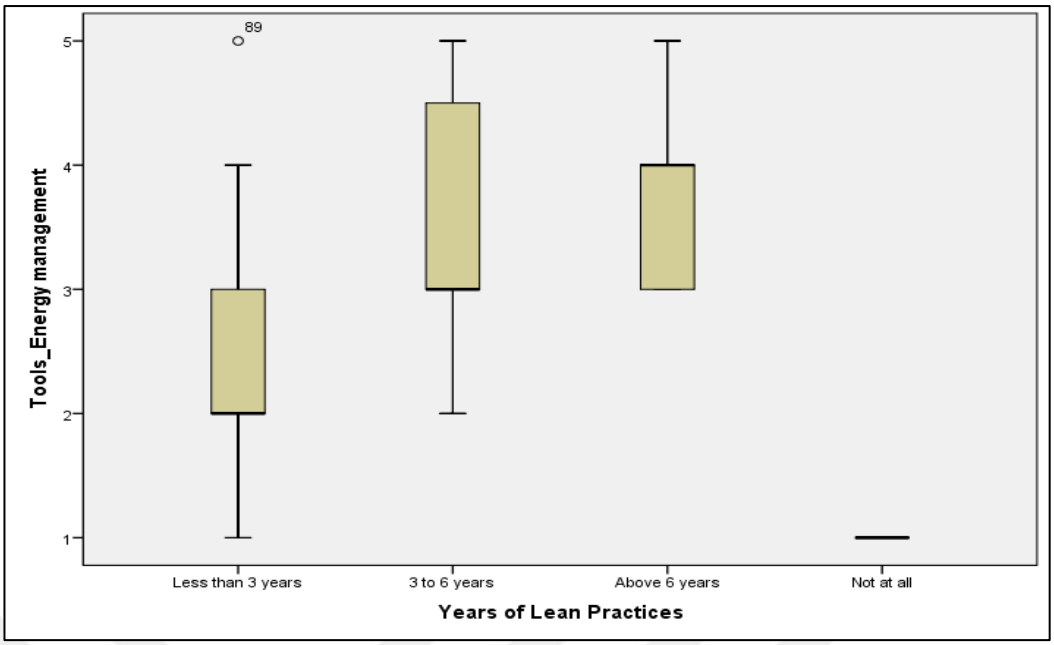

Figure 4.14: Energy Management based on Lean experience

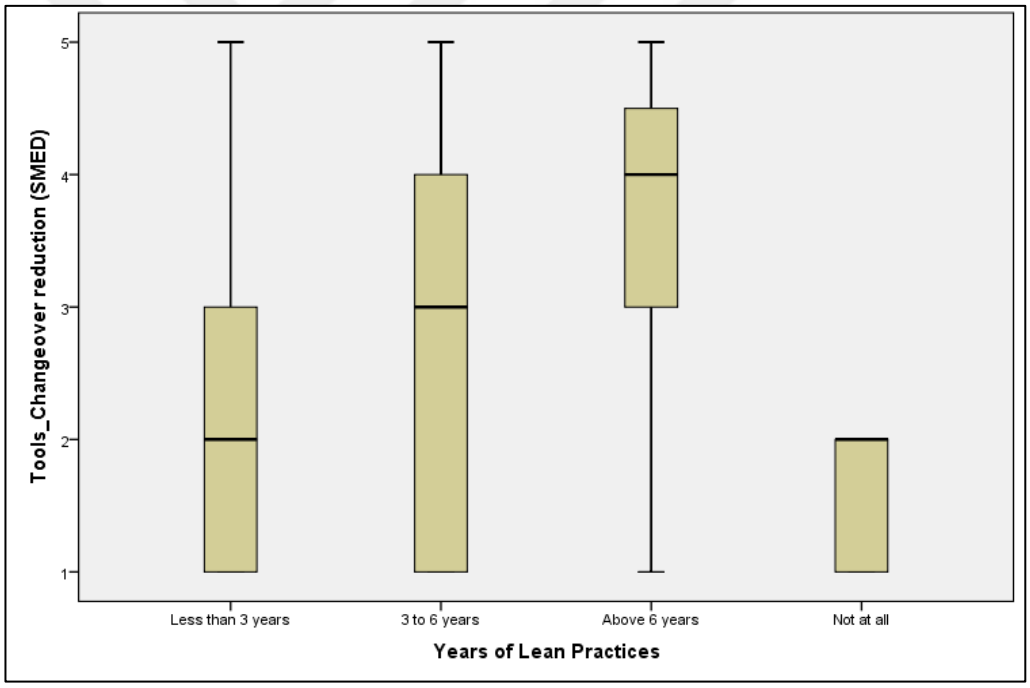

Figure 4.15: Changeover reduction based on Lean experience

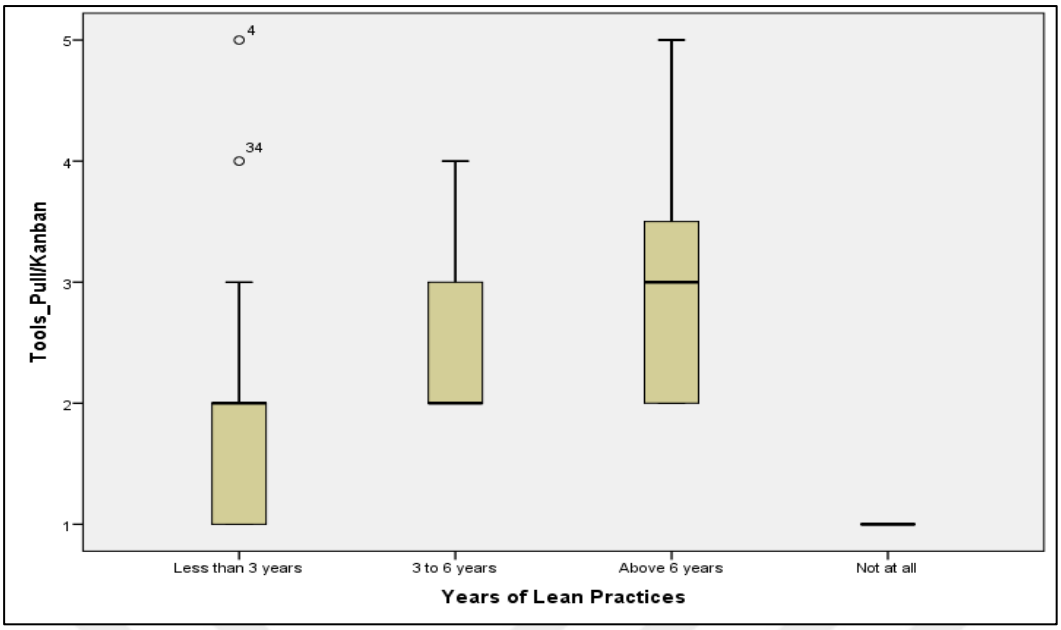

Figure 4.16: Pull/Kanban based on Lean experience

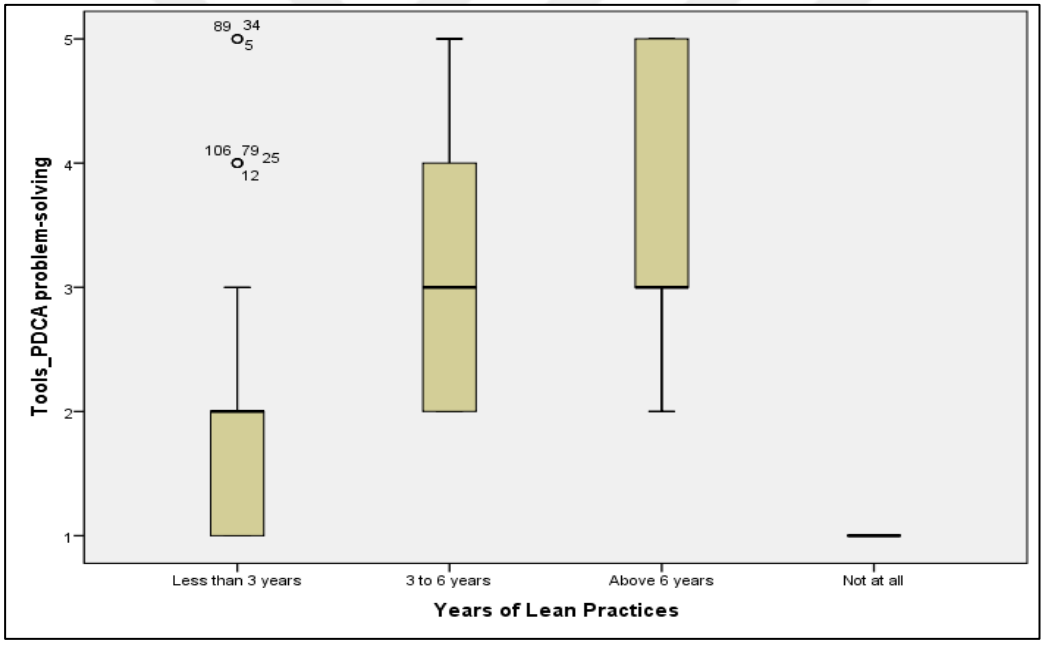

Figure 4.17: PDCA Problem Solving based on Lean experience

Figure 4.18: Process Mapping based on Lean experience

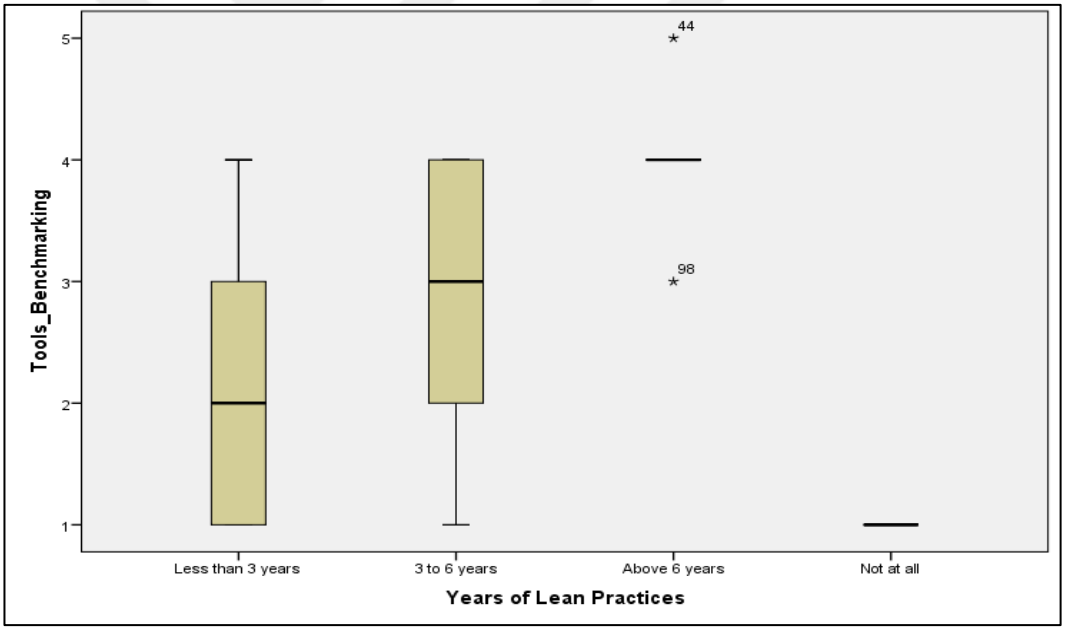

Figure 4.19: Benchmarking based on Lean experience

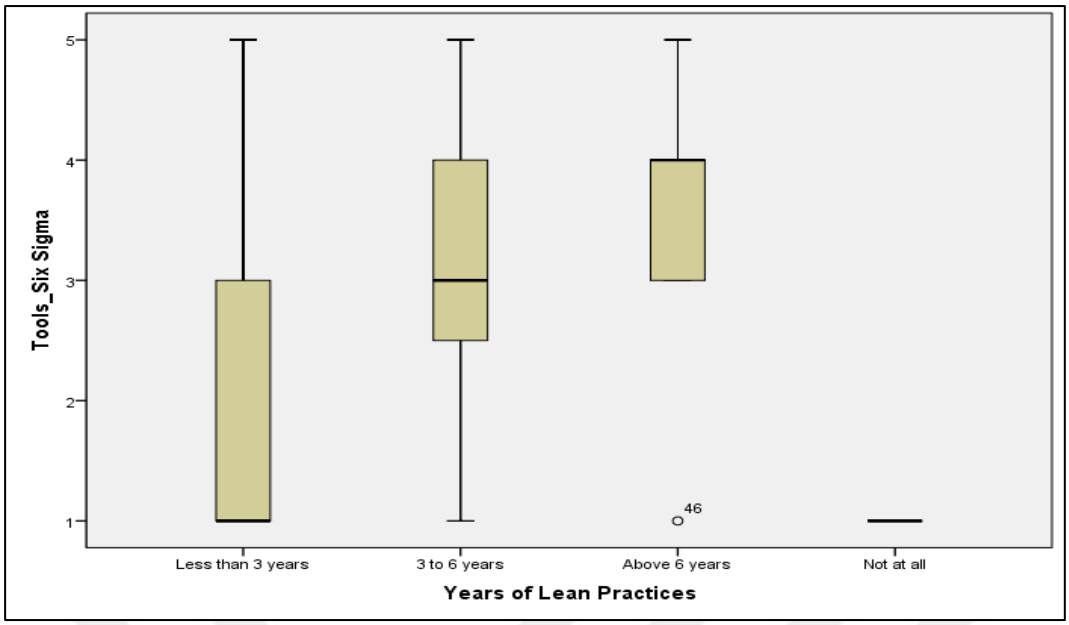

Figure 4.20: Six Sigma based on Lean experience

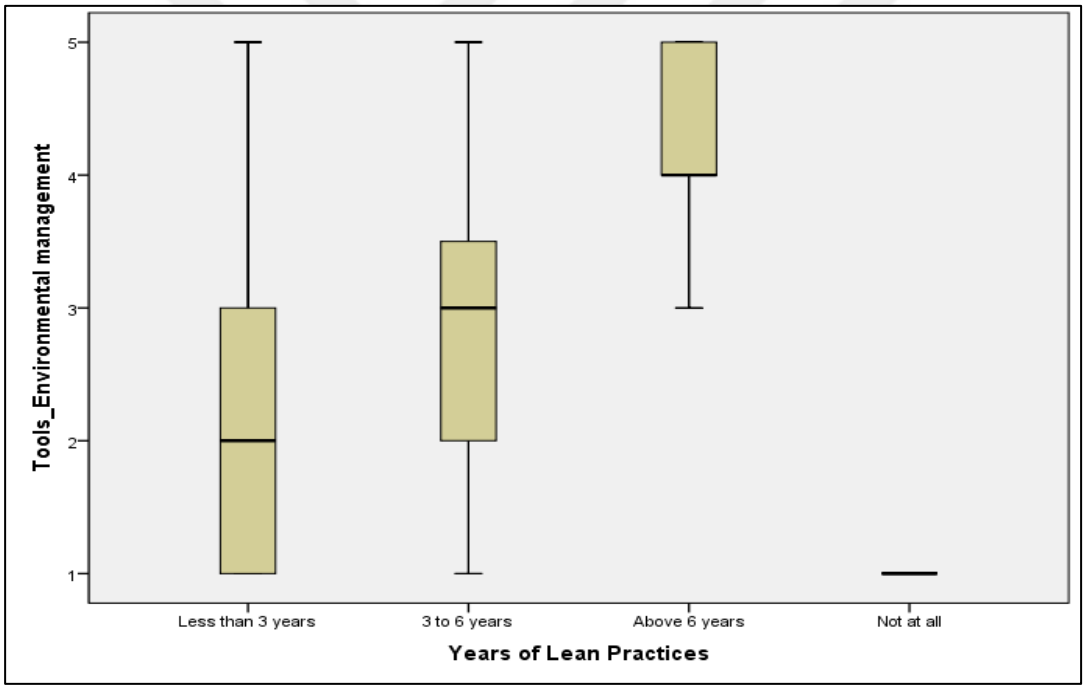

Figure 4.21: Environmental Management based on Lean experience

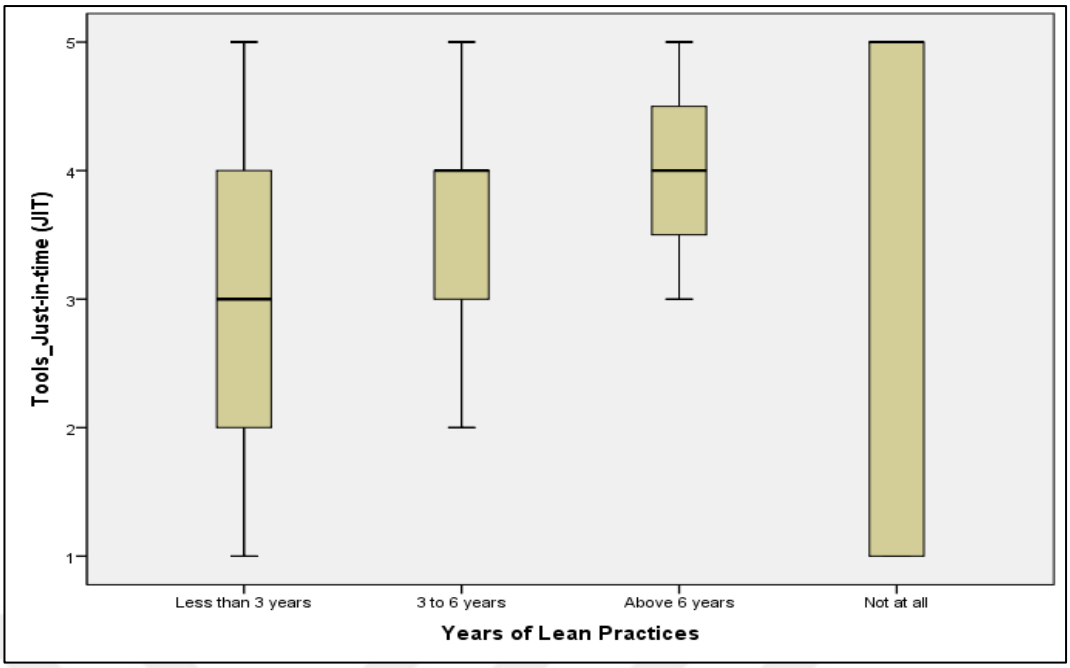

Figure 4.22: Just-in-time based on Lean experience

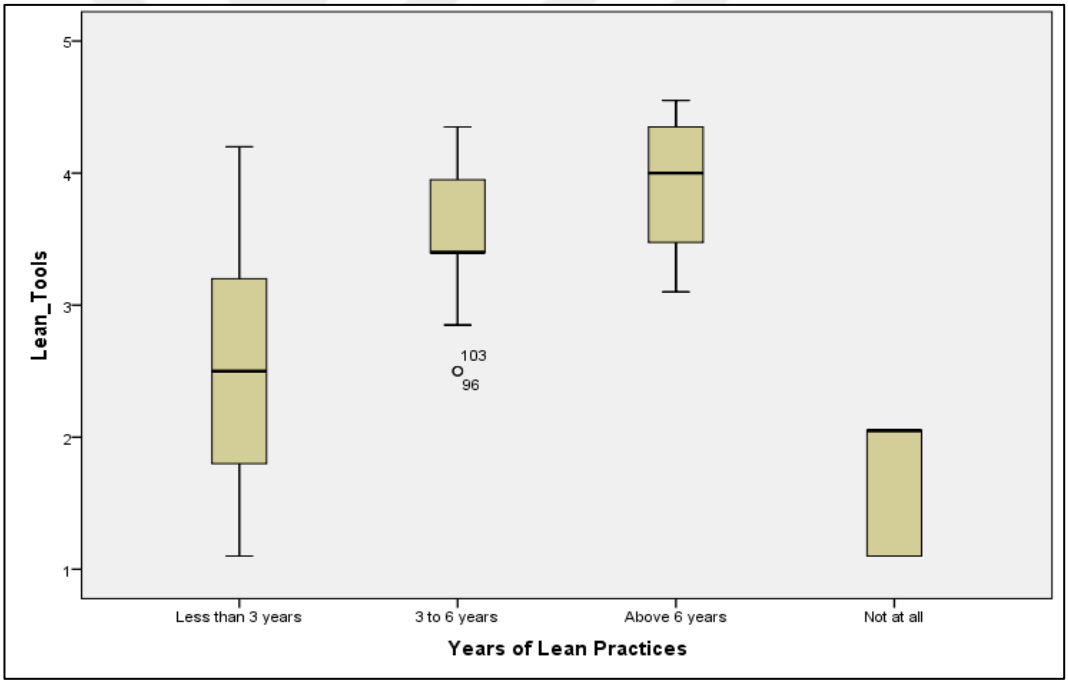

Figure 4.23: Lean implementation based on Lean experience

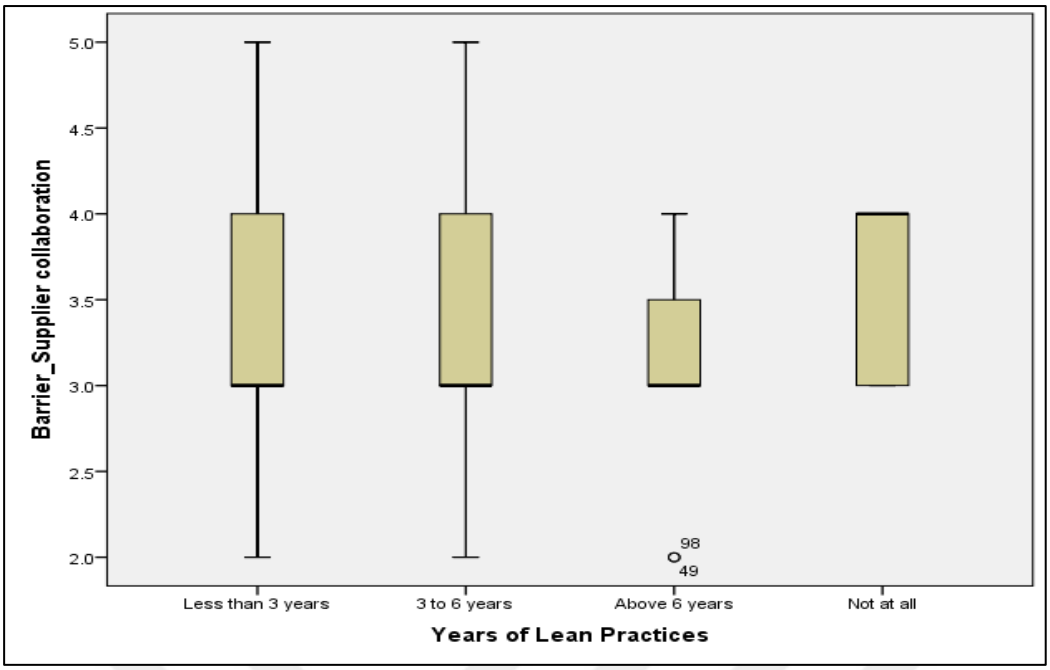

Figure 4.32: Supplier Collaboration barrier based on lean experience

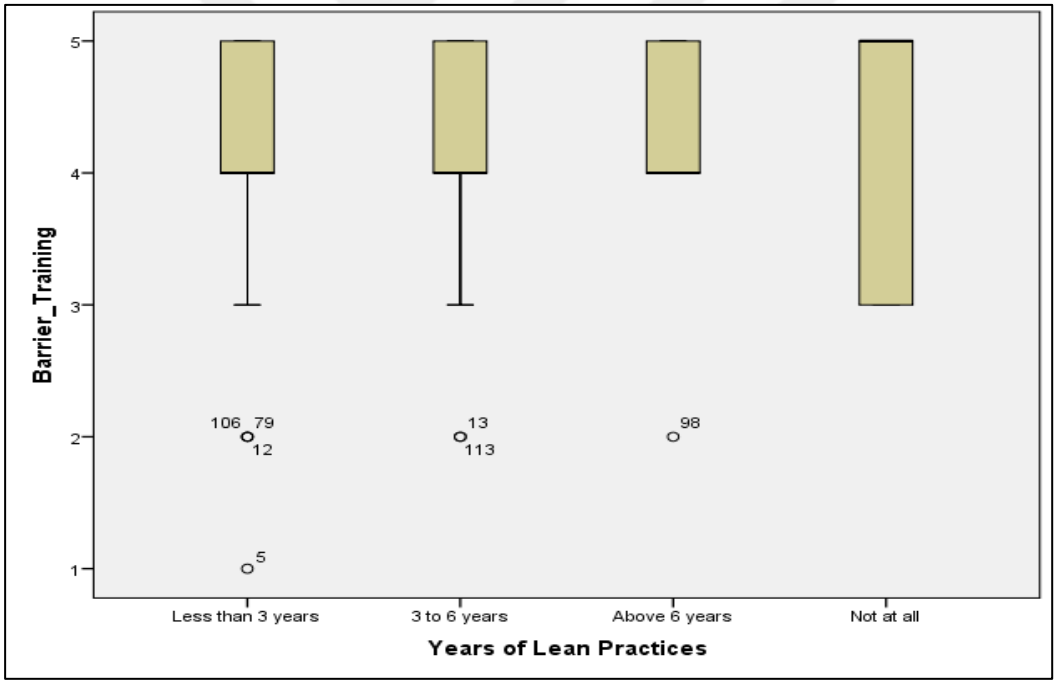

Figure 4.33: Training barrier based on lean experience

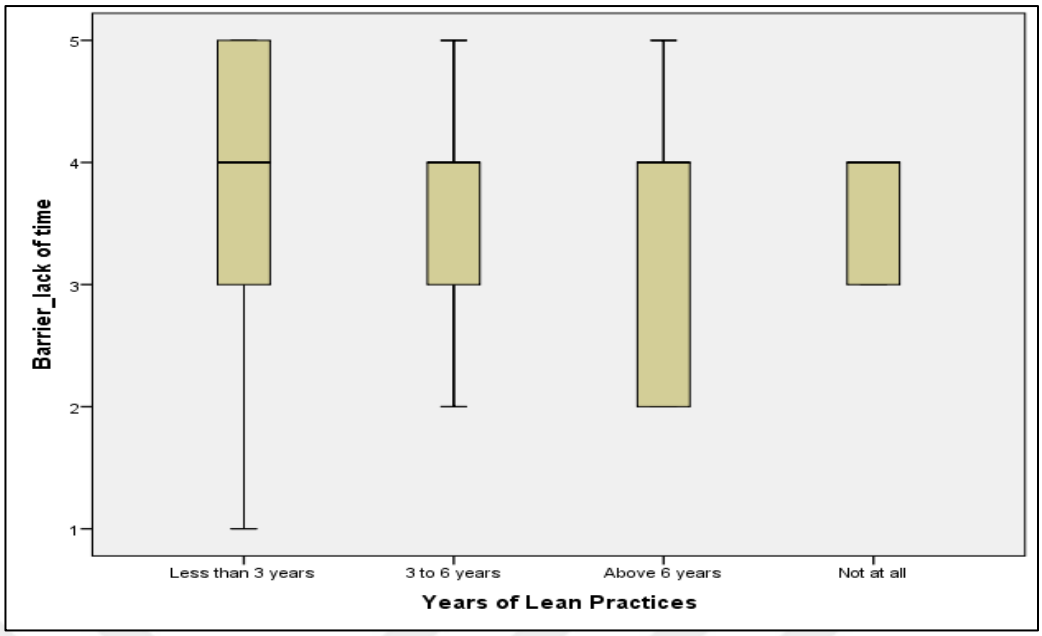

Figure 4.34: Lack of time barrier based on lean experience

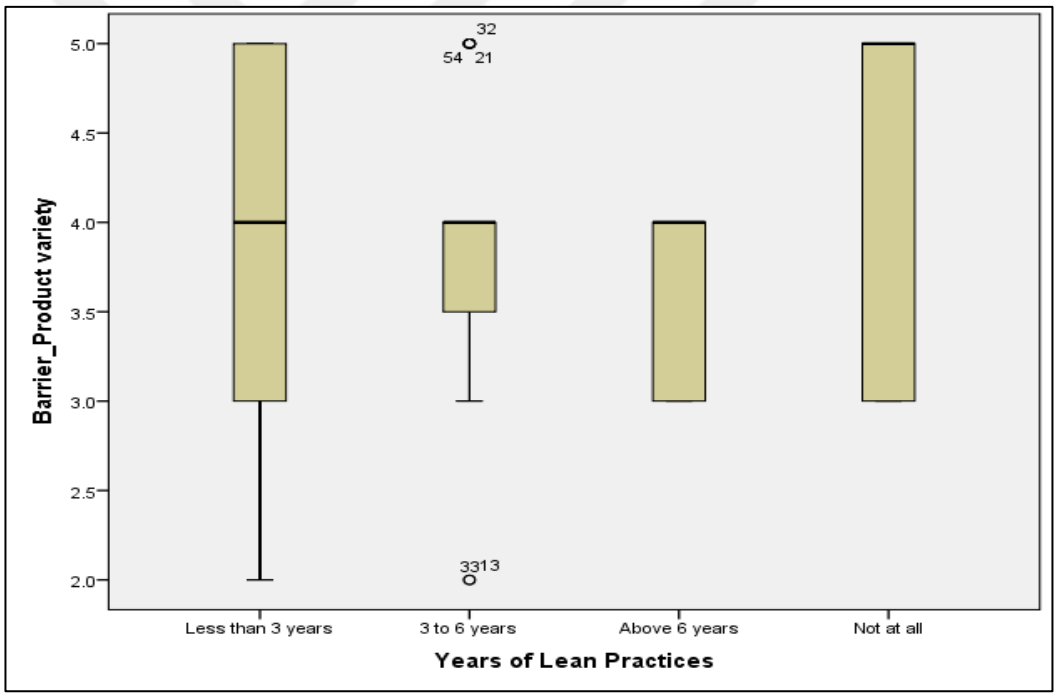

Figure 4.35: Product Variety barrier based on lean experience

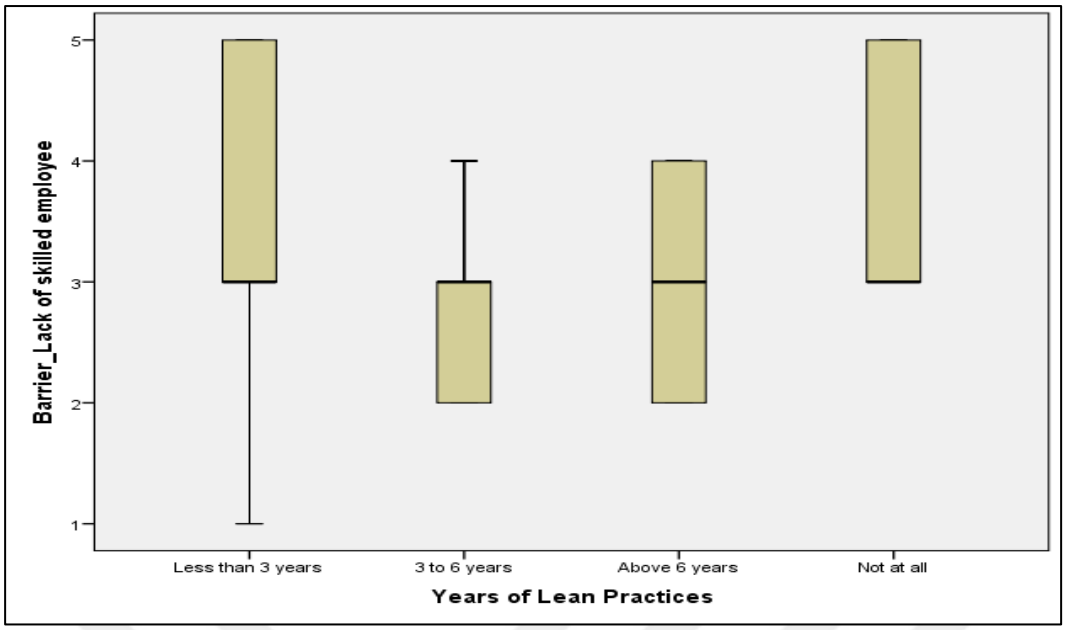

Figure 4.36: Lack of skilled employee barrier based on lean experience

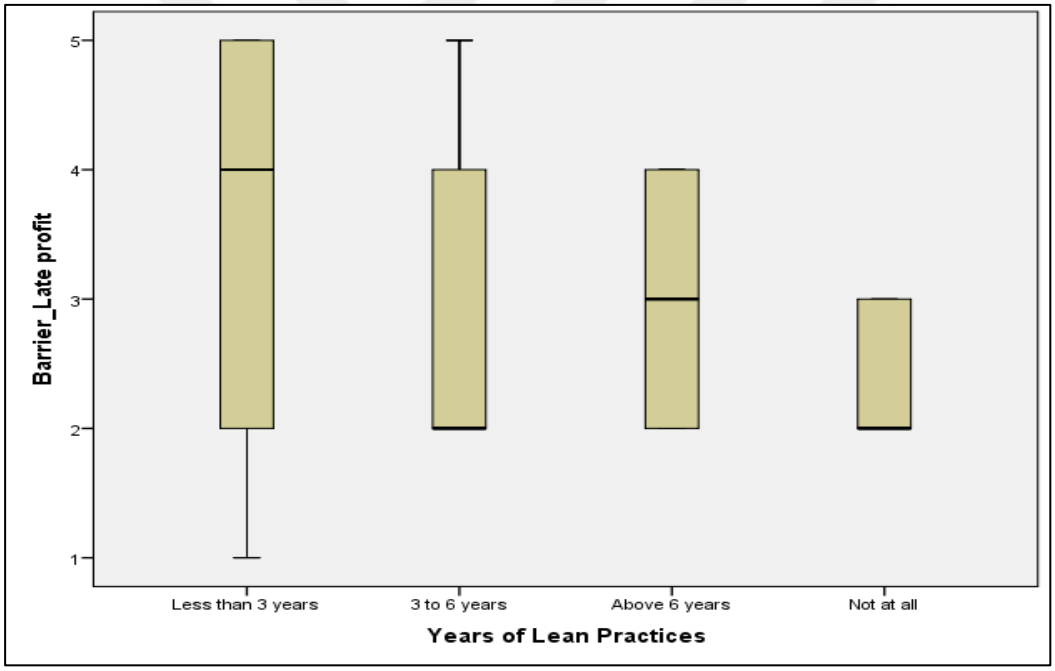

Figure 4.37: Late Profit barrier based on lean experience

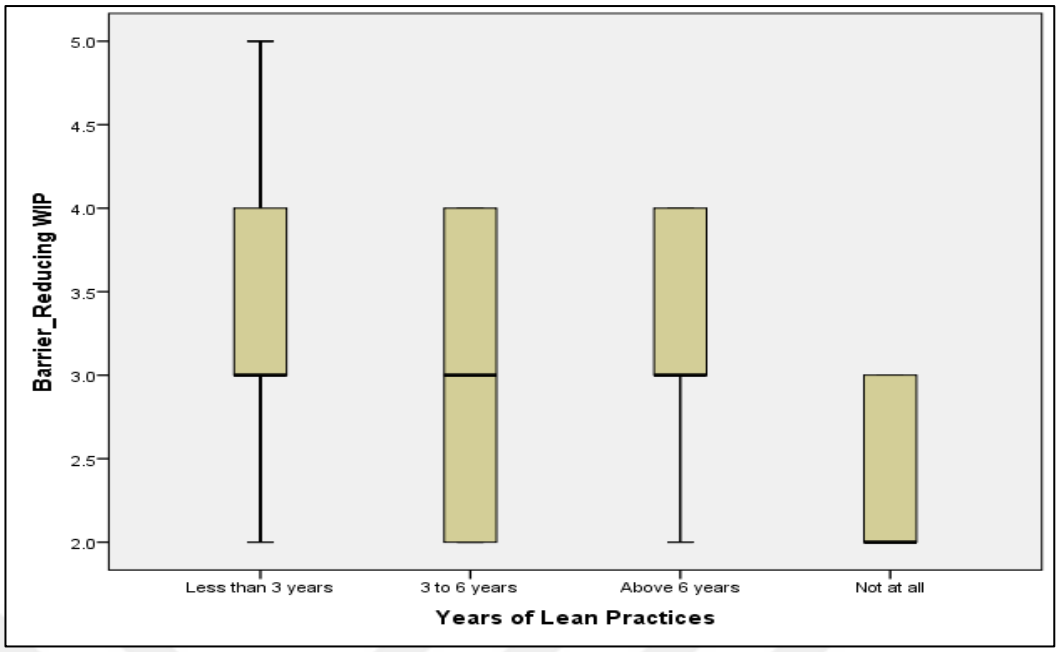

Figure 4.38: Reducing WIP barrier based on lean experience

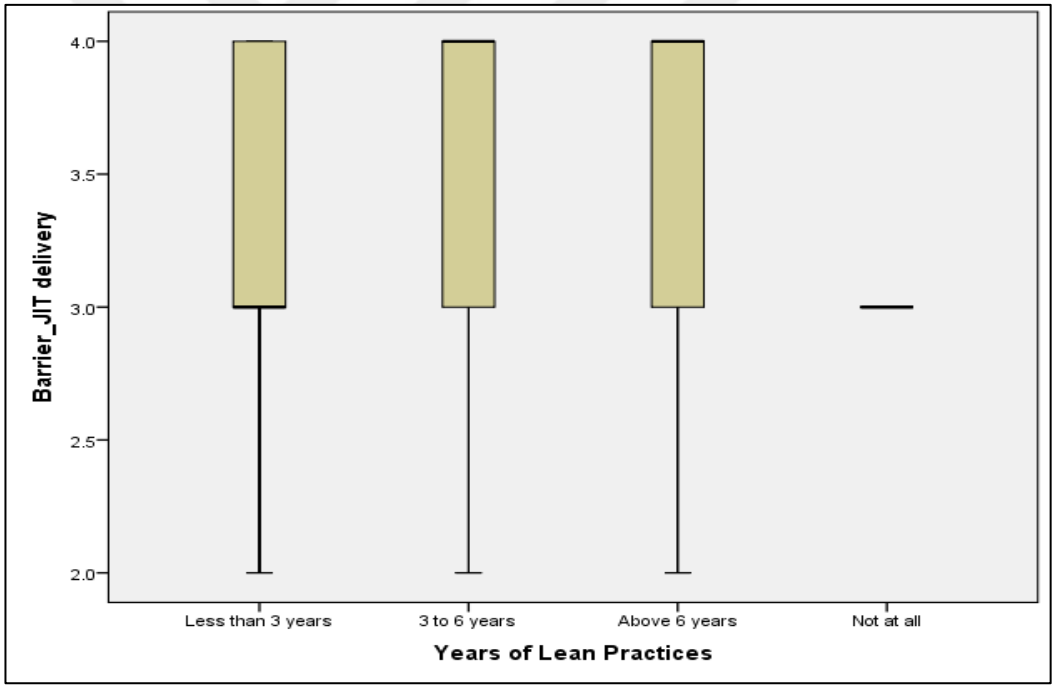

Figure 4.39: JIT delivery barrier based on lean experience

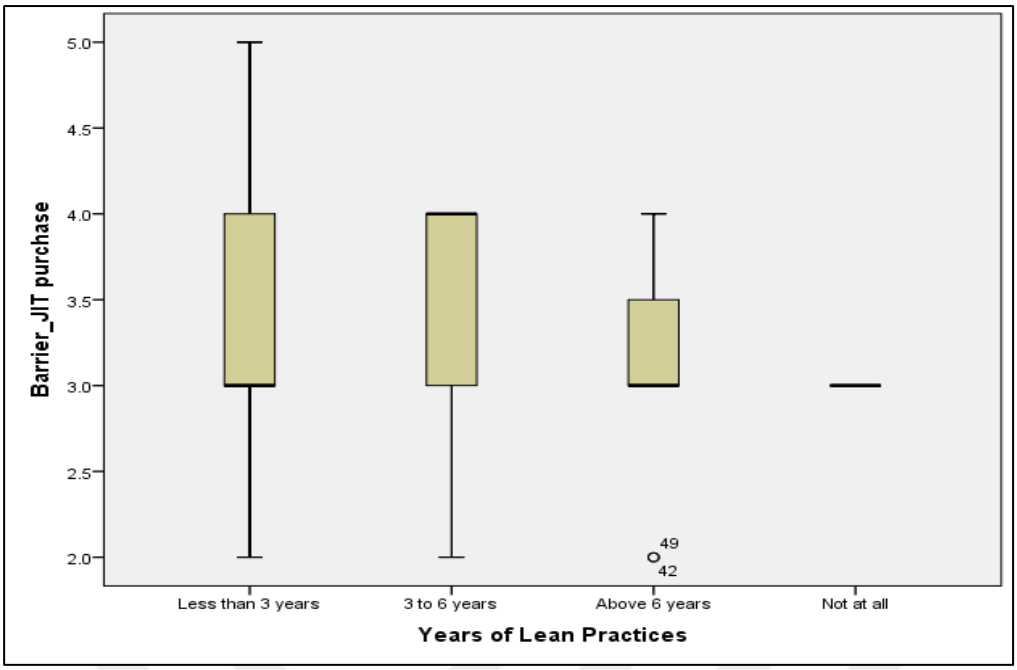

Figure 4.40: JIT purchase barrier based on lean experience

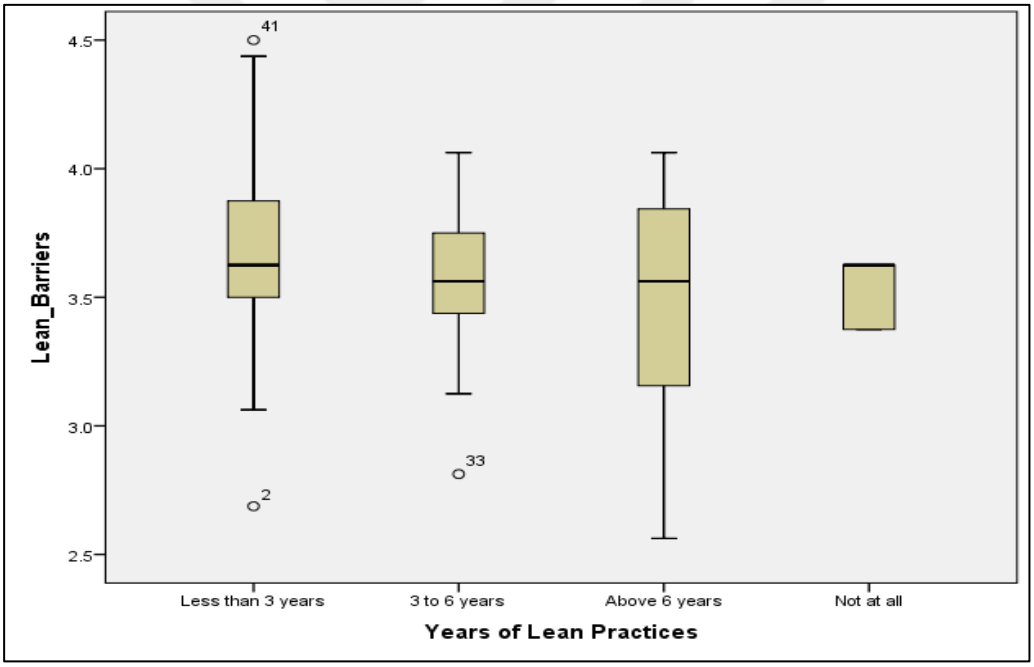

Figure 4.41: Overall lean barrier based on lean experience

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