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Lean Practices in the Textile Industry - a Comparison of Cases from India, the US, and Bangladesh

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Master of Engineering

Thesis for a Master of Industrial Management and Engineering (UAS) – degree

Vaasa 2023

MASTER THESIS

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Degree Programme and Place of Study: Industrial Management and Engineering, Vaasa
Supervisor(s): Roger Nylund

Title: Lean Practices in the Textile Industry- a Comparison of Cases from India, the US, and Bangladesh

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Date: 24.05.2023 Number of pages: 86 Appendices: 0

Abstract

The textile industry plays a significant role in the global economy, with countries such as India, the United States, and Bangladesh emerging as crucial players in textile production and export. In recent years, there has been a growing interest in implementing lean practices in the textile industry to improve operational efficiency, reduce waste, and enhance overall competitiveness. This thesis aims to compare and analyze the application of lean practices in the textile industries of India, the United States, and Bangladesh, focusing on identifying similarities, differences, and best practices.

The study adopts a qualitative research approach, utilizing case studies as the secondary data collection method. Three textile manufacturing companies, one from each country, will be selected as case studies based on their size, industry reputation, and willingness to participate. Data will be collected through interviews, on-site observations, and document analysis, providing a comprehensive understanding of lean implementation strategies and outcomes.

The comparative analysis will focus on various aspects of lean practices, including process optimization, waste reduction, supply chain management, employee involvement, and continuous improvement initiatives. The findings of this research will shed light on the contextual factors that influence the adoption and success of lean practices in the textile industry across different countries.

The outcome of this study is to provide valuable insights and recommendations for textile industry stakeholders, including manufacturers, policymakers, and practitioners, on how to implement lean practices in their respective contexts effectively. Furthermore, the comparative analysis contributes to the literature on lean manufacturing, offering a cross-country perspective on the challenges and opportunities associated with lean adoption in the textile industry.

Language: English
Key Words: lean practices, textile industry, comparative analysis, waste reduction.

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1 Introduction

Reduced manufacturing expenses, production time, and quality control costs significantly impact the industry's internal economy. Eliminating ineffective methods is crucial for industry management to maintain a healthy industrial economy. In light of this, management has decided to investigate and implement lean Manufacturing in the textile industry. Lean Manufacturing, which originated and evolved in Japan, can be considered a corporate strategy seeking to identify and eliminate waste (Deshmukh et al., 2022). This leads to a more cost-effective improvement in production and service management quality and profitability than would otherwise occur (De la Vega-Rodríguez et al.,2018). The textile industry in Bangladesh has made efforts to apply this, but more research is needed to determine whether it is acceptable. This study will show how well the lean manufacturing approach benefited Bangladesh's textile industry compared to other countries. Envisioning the various waste types generated in the sector and probable future effects of dumping or reducing them Utilizing secondary data and observations, this research will be conducted utilizing several case studies based on the lean manufacturing model in the textile sectors of Bangladesh and other nations. The outcome of this perception was that the industry might gain from the legal application of lean Manufacturing and achieve higher levels of efficiency. (Islam et al., 2013).

1.1 Study Background

In Bangladesh, the ready-to-wear and textile industries started in the late 1970s, expanded enormously in the 1980s, and exploded in the 1990s. The concomitant uniqueness of the business, such as the less complicated technology, affordable and efficient machinery, and a low-cost substantial mainly female staff, allowed for the rapid development of the business. Bangladesh contributes less than 5% to the global textile industry, which accounts for 75% of all export revenue in Bangladesh. Bangladesh's economy, which is heavily dependent on its subsector, will now have to fight against textile powerhouses like China and India because the tax-free quota and GSP have been closed, and the trading environment has become intensely

focused. (Sultana and Islam, 2013)

The internal economics of the industry is significantly impacted when production costs, production time, and quality control costs are reduced. In order to keep a healthy industrial economy, it is essential for management in industries to do away with unsuccessful practices.

Previous internal and external studies have recommended eliminating wasteful elements and anomalies, explicitly cutting down on production lead time and wastages in the nation's textile sectors and 11 exporting operations. Utilizing lean manufacturing concepts can present the textile sector with several possible development prospects despite the highly competitive business environment (Ejsmont et al., 2020). This is due to how business is conducted in the export-based readymade textile industry. The growth of profound effectiveness through a reduction in the total amount of time required for "production and conveyance" would improve surface-level effectiveness by reducing the amount of time required for "lead time." (Dominici et al., 2013).

"Clothing" refers to all items worn on the human body. The definitions of apparel and garment are nearly identical. Clothing of a specific sort is considered apparel when sold in a store. A garment is a type of fabric. Textiles, animal skin, and other wearable materials can be combined to create clothing. A manufactured or natural fiber network, such as yarn or thread, makes up a textile, which is a flexible material. Raw cotton, wool, hemp, flax, and other fibers are spun into long strings or strands to create yarn. The primary products of textile industries were textile and clothing. Several of which generate both. Weaving, knitting, tatting, knotting, crocheting, braiding, or felting are used to create textiles.

1.2 Research Objectives and Research Questions

The primary objective of this study is to investigate the degree to which the textile industry in Bangladesh uses lean manufacturing principles. Investigate how lean manufacturing improves

production performance and identify the components of an environment conducive to the successful application of lean principles. The purpose of this inquiry is to carry out a comparative study to investigate the relationship between the current investigation's outcomes and previous global investigations' outcomes, looking at similar ways of insight.

Lean manufacturing principles have spread worldwide since they were created in Japan. These practices are used in both developing and industrialized nations. Bangladesh is relatively new in terms of the number of countries that use lean compared to other countries. Industries with assembly facilities and industries that require significant amounts of human engagement in manufacturing are the most likely to use lean manufacturing. In most cases, the ability and focus of the people working physically with machines or other types of working gear, such as in the textile industry, has a significant bearing on the level of profitability that the business generates. The purpose of this study is to analyze the implementation of lean techniques within the textile industries of Bangladesh and determine the impact these practices have had on overall performance. The key research questions (RQ) in light of the initial interest, as well as the difficulties that have persisted in Bangladesh's textile industries, are as follows:

RQ1: What kinds of lean methods are used in Bangladesh's textile sectors in order to boost production performance, and how exactly are these implementations carried out?

The Case studies and empirical data chapter answer this research question. This section will discuss lean in Bangladeshi textile businesses through articles, scientific papers, case studies, and other published materials. This section discusses lean approaches in India, the US, and other nations.

RQ2: To what extent did Bangladesh's textile sector benefit from implementing lean manufacturing practices, and what kind of results did these practices achieve, as compared to those generated in other nations that used lean manufacturing practices?

Data analysis and discussion will address the third research topic. This chapter compares Bangladesh's textile industries' lean system implementation to worldwide practices. That chapter will also present lean practice benefits to derive the conclusion.

1.3 Research Process

The purpose of this study is to identify and evaluate the research on the relationship between lean and the extent of lean implementation in Bangladesh, as well as the relationship between lean and sustainability, and to organize the essential articles to identify potential research gaps, issues, and opportunities. This article will aid in better understanding lean manufacturing practices and industry challenges. The literature review is an advanced phase identifying developing research fields requiring additional investigation. (Durach et al., 2021). A literature review adds to theory creation (Seuring and Müller, 2008) and can aid in determining the conceptual content of the area of research (Meredith, 1993).

Internet and numerous databases are the most cost-effective and compelling means of disseminating research. This "web for learning," commonly known as the "internet," is a portal to the most extensive reference databases in the world, collecting articles from uncountable magazines and books from all over the world and papers given at countless conferences. Nonetheless, valuable and worthless, convenient and inconvenient information is abundant. To begin searching for high-quality research papers, researchers must first pick keywords pertinent to their study questions and then thoroughly search for relevant sources. This includes Google Scholar and other reputable periodicals such as Emerald, Springer, Taylor & Francis, IEEE, and Elsevier publishers.

Figure 1 below depicts a high-level view of the research procedure. The study's scope and methodology, as well as some contextual information, are laid out in the first chapter. In addition to supporting the rationale behind choosing this particular topic for investigation, this section delineates the study's goals and provides a framework for conducting the study.

Chapter two reviews the literature. This specifies key research terms, theoretical models, and conceptual frameworks. This chapter introduces prior research and analytic strategies, philosophies, and studies by other writers with similar research goals.

Chapter three covers the approach. This chapter outlines the research method. That section discusses the research design, data gathering method, data collection considerations, and research philosophy.

Chapter four covers case studies, empirical data collection, and presentation. Charts, figures, and detailed explanations help secondary data collection, observations, and case studies.

Chapter five analyzes and discusses data. This part addresses essential research goals. Data analysis compares research data to literature review studies. This section describes the research questions and aims.

The sixth chapter concludes the thesis.. This chapter summarizes the research goal and objective achievement. It will also suggest future research and acknowledge the study's flaws.

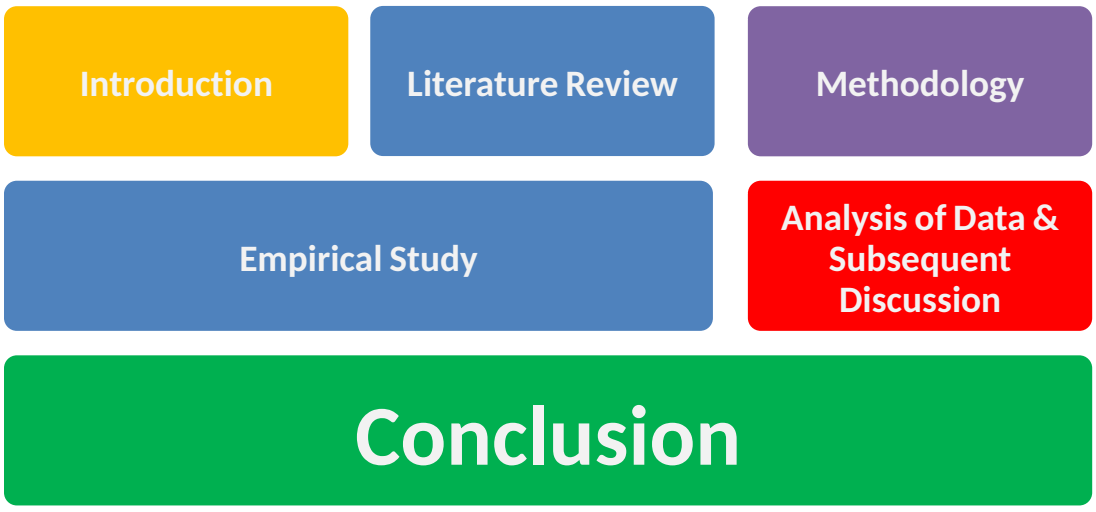

Figure 1: Research Plan Structure

2 Literature Review

2.1 Lean Approach and Management

Lean production incorporates continuous improvements, having a small organization system, working together, having skilled inventory, and waste elimination. (Chen et al., 2010).

The 2007 popular seller The Machine That Changed the World: The Story of Lean Production Toyota's secret weapon in the global car wars that is now revolutionizing world industry (Bell, S. 2005). This book follows vehicle manufacturing from small-scale through large-scale to lean production. Henry Ford formalized vehicle parts and assembly techniques so that low-skilled people and specific equipment could create affordable cars for the masses. Large-scale manufacturers produced cheaper cars than craft production, but preparation, design, and administration were problems. The book then describes how a small firm wanted to build cars for Japan but needed help to afford the massive investment in single-purpose equipment. For large-scale manufacturing, indirect labor and inventory were necessary. Thus, it improved productivity by reducing inventory and delegating leadership to production workers. The Toyota Production System, known as "lean production," grew from tiny production units into a vast corporation.

2.1.1 Genesis of Lean Thinking

This idea has been used by the Japanese to get rid of waste, which has allowed them to reduce the costs associated with any activity, whether in the service or manufacturing sectors. Lean production spans the whole production procedure, beginning with product planning and ending with supply chain linkages (Gergova, I. 2010).

With lean, cycle times can be reduced and when they get it by eliminating all kinds of waste during production. Lean principles and approaches revolve around building a community that builds relationships with employees and reduces the time, money, and resources needed to meet customers' needs (Gothelf, J. 2013). By eliminating waste, this operational system focuses on making the process last as little time as possible. This procedure is meant to do the work included more effectively by cutting down on the work done by accident. This system increases productivity by lowering costs and understanding how significant value is to the customer since value is the most critical factor in lean production. Businesses now are well aware of lean's value and employ the practice

Even 10 years ago, production strategy was considered a crazy choice compared to traditional manufacturing types (Achillas et al., 2015). However, it serves as a template for actions, and its ripple effects may be observed in various ways to put things together and serve people. Processing plants all over the world see the benefits of lean production. Organizations report a shorter process time, better product quality, less work in progress, faster delivery, lower costs, more overall profit, better use of labor, fewer stocks, speedier capital adventure profits through increased output, elasticity, efficiency in space utilization, less device speculation, more focused work, better use of instruments, and enhanced proficiency development across the board, from production to customer service (Pavnaskar et al., 2003).

Lean manufacturing is a system for optimizing production that relies on a small number of core metrics and techniques (Sundar et al., 2014). This helps to reach the production goal and get the product to the right place at the right time. These things affect just-in-time (JIT) production and transportation at the right time. This helps an organization be competitive when done in a coordinated way. As was already said, the main focus of lean Production is on the industrial stream. Because of this, the standard batch capacity is not necessarily the best one to use, as each manufacturing process decides the batch size. Products, not processes, should make up the work cells if a continuous flow is to be achieved. (Rother et al., 2001). This change necessitates standardized procedures in a clean, well-organized, and modern atmosphere, with just-in-time production and employee engagement in an all-encompassing improvement framework (Cheng et al., 1996). There are five fundamental ideas of Lean Manufacturing.

(Čiarnienė et al., 2012).

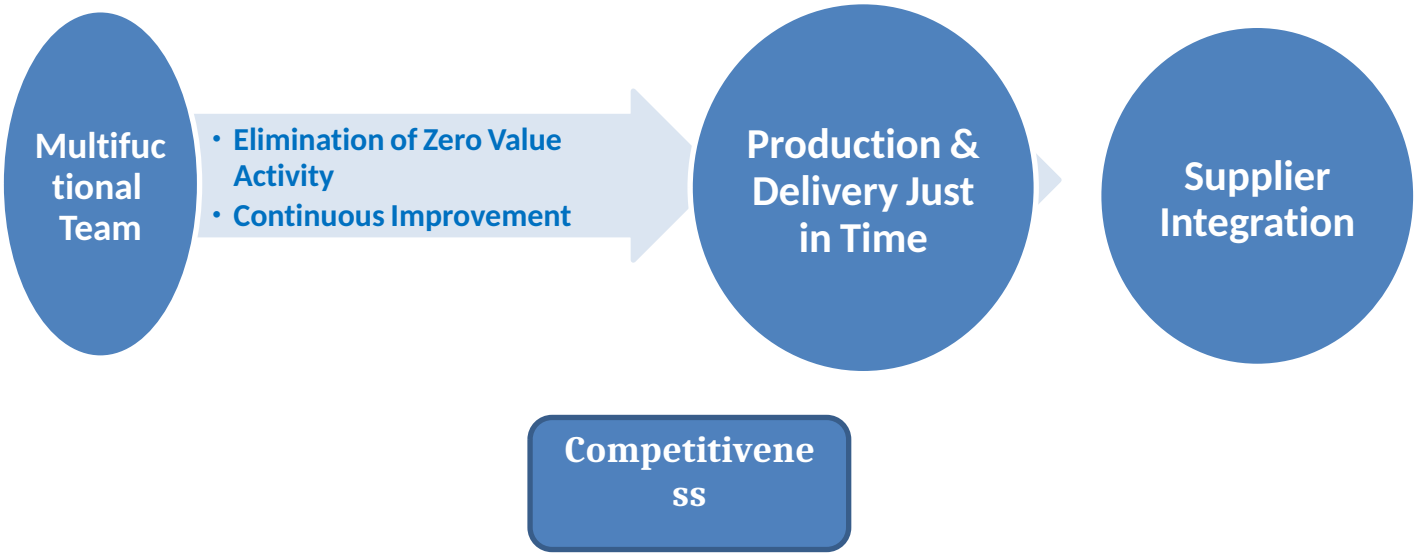

Figure 2: The Concept of Lean Production (Modified from Sanchez and Perez, 2001)

2.1.2 Toyota Production System (TPS)

Toyota was the pioneer in the use of lean production methods. (Yamamoto et al., 2019). The Toyota Production System was a well-known name for this framework. This system of making things has exercises that increase an incentive by reducing waste. Taichi Ohno, the vice president of Toyota, created the Toyota Production System. He is known as the "father" of the Toyota Production System (Ohno, T. 1988). Production using this model can either increase profit or reduce waste. The Toyota Production System has paid much attention to how hard it is to define value and develop an elegant solution.

During and after World War II, large-scale production systems forced companies to compete hard in the market. This made the Toyota Motor Company look closely at the American auto industry's production assembly line (Liker, J. K. 2021)). Toyota's plan led to a complete reorganization of the company, creating a new manufacturing system called the TPS. Its goal was to eliminate any waste in the manufacturing process as quickly as possible (Chiarini, A. 2012). In 1949, Eiji Toyota went to Ford, the most prominent car company in the world, and noticed there was trash all throughout the place (Hino, S. 2005). There was a Muda of transportation, Muda of employment, inventory and management of abundance, Muda of faults, Muda of facilities, and Muda of delay (Arunagir et al., 2014).

Henry Ford's methods of disposal from the early 1900s inspired Toyota to create a hierarchical culture that focuses on efficiency, simple labeling, and the elimination of unnecessary components in production (Charron et al., 2014). The idea came from Toyota, but many other businesses and organizations have used it. Toyota's market leadership in the business world is due to its ability to deal with the growing challenges of staying in business using a lean manufacturing framework. Toyota pioneered "lean manufacturing," an approach to streamlining production that emphasises eliminating wasteful processes while maintaining high standards of quality, efficiency, and productivity. (Yamamoto et al., 2019). Toyota's Production System focuses on reducing and eliminating waste in the factory environment (Tohidi et al., 2012). TPS includes 5S, taking suggestions, warning about mistakes, full safety measures, constant observation, and routine procedures. Toyota received more than 700,000 ideas for improving things from workers at all levels during a test year, and more than 99 percent of them were implemented. So, the organization was able to compete on a global scale like never before (Miller, J. 2003). Because of Toyota's success with lean implementation, businesses across a wide range of sectors have adopted some of the company's groundbreaking approaches to mass production. (Piercy et al., 2003). A 2004 book by Liker describes Toyota's business practises and claims the company is the most significant in the globe.

2.1.3 Five Keys to Lean Management

The five core Lean principles can be used to implement consistent change in any industry, whether it be service or production (Thomas et al., 2016)These ideas were first shown by Womack and Jones in 1996 (Hines et al., 2004). Melton (2005) makes some assumptions about the rules, such as value, and esteem flow, are shown below:

The first step is to figure out what the client thinks the value is. Production-based businesses are more likely to sell items that make money for the makers than to focus on making things that customers will want (Turner et al., 2019). Therefore, they need to create a product line in response to market demand. This makes them have to use the Lean method and guess numbers (Melicheret al.,2016).

The second is the value stream, which entails shaping the flow of resources toward particular customers in accordance with their wants rather than the requirements of specific manufacturing divisions. (Peppard et al., 2006).

The third rule or rule of thumb ensures processes, people, and culture have been looked into (Klepper, S. 1997). It is also used to keep critical value-added tasks from being put off and to get rid of tasks that do not add value.

The fourth principle is using pull, eliminating extra production by focusing on what customers want (Hicks et al., 2007).

The fifth rule is to try to do everything perfectly. Improving quality is part of flawlessness or perfection, as is making what customers want just-in-time, at a fair price, and with no waste(Abdulmalek et al., 2007). This means that the development cycle should not end and should continue (Griffin, A. 1997).

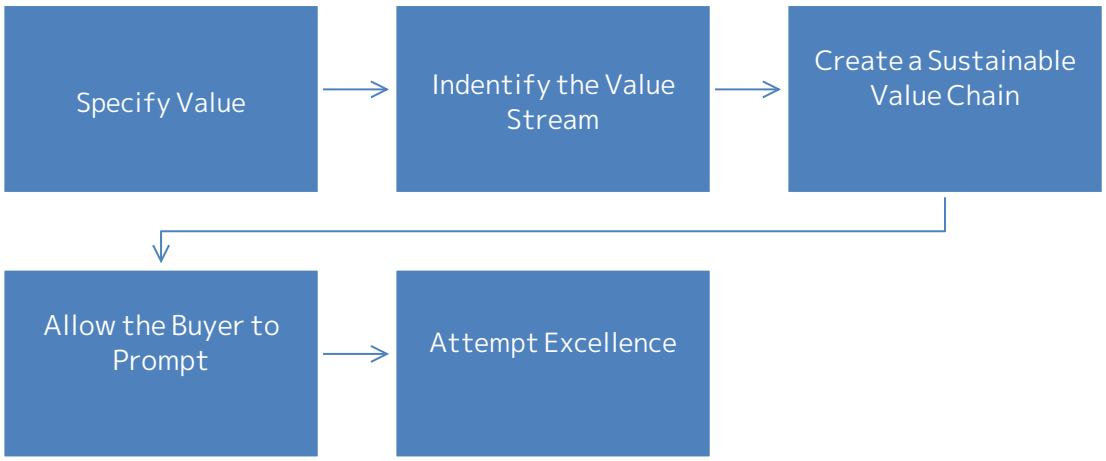

Figure 3: The Five Principles of Lean (Modified from Lay et al., 2009)

The subsequent five criteria were first made for the manufacturing industry but can also be used in the service industry. The five standards are shown in Figure 3. The second tenet is the cornerstone. Differentiating customer-beneficial process evidence is a primary focus. A value stream is a useful tool for this purpose in manufacturing and other production-oriented sectors. The rest of the rules for service-based businesses are the same as for production-based businesses (Lay et al., 2009).

2.1.4 Seven wastes of Lean

Overproduction

When services and things are produced a fast and too often, which leads to excess manufacturing, there is more waste. This kind of loss is made in the production process with a "just-in-case" instead of a "just-in-time" mindset (Crawford et al., 2020). This kind of loss can happen if business decides to only make as much as is needed. Copies made by no one in the company will use that to help the customer end up as waste, which causes costs and an increase in unwanted stock in the long run. Overproduction, according to Ohno, is the primary source of

waste since it causes problems for businesses (Oliveira et al., 2017).

Waiting

Poor time management causes delays and frustration. One of the essential principles of Lean reasoning is that too much holding up interrupts the flow of production and management. Waiting is a waste of time when, for example, a machine breaks down and needs to be fixed by a specialist before work can get done or a decision can be made. More waiting time has been linked to longer lead times, decreased client retention, and market share (Anderson et al., 1994).

Motion

Both people and machines cause waste in motion or mobility. The human parts of waste in motion are caused by how well workers do their jobs, which is called ergonomics. When an office needs to be set up better, it is hard to get to documents or other things that should be nearby but are not. It also makes people move and switch jobs more than they need to, which is stressful (Colquitt et al., 2014). Poor ergonomics at work can have a significant effect on health, productivity, and the quality of the work (Shikdar et al ., 2003)

Transport

It is wasteful to move materials or goods from one location to another if doing so does not improve the product for the consumer. This includes transporting resources, products, or actual customers. Moving and transporting clients from one office to another or workstation to another is an example of garbage hauling (Liskov, B., & Ladin, R. 1986).

Inventory

Discarded initial resources, WIP, and completed goods are all examples of surplus inventory, which is classified as inventory waste (Sullivan et al., 2002). Incongruous stock retention wastes time by impeding work continuity, occupying an extra room that could slow down

communication and collaboration among departments, lengthening the time it takes to get products to customers, and making it harder to find certain items in a pinch (Kanter, R. M. 2006).

Extra-Processing

Not being able to tell employees what clients need, not being able to communicate with clients and not understanding what they want, and not being able to make what clients want. For instance, this kind of waste happens when too many reports are made, and they are too long and complicated (Ioannidis et al., 2014).

Defects

Defects cause damage to resources, time, money, and energy with every occurrence of waste. Reproducing something forces an employee to repeat an error; remaking doubles production duration and expenses, leaves customers unhappy, and can even lead to a decline in business. More than 1.6 million Toyota vehicles in 2013 were recalled due to defective airbags. This costs them a lot of money and may even damage their reputation (Klyatis, L. M. 2020).

2.1.5 Lean Methods and Equipment

Lean Six Sigma

The term "Six Sigma" (6) quality was used by Motorola to define the company's approach to minimising errors. Six Sigma refers to the number 99.9996%, meaning that there are almost no mistakes. Lean Six Sigma combines the Six Sigma method with tools for making things more efficient. Based on data, Lean Six Sigma is a way to find the root causes of problems. Executives might use this method to manage lean tasks to achieve budgetary targets. It uses the DMAIC (define, measure, analyze, improve, and maintain) method to organize working procedures (Nandakumar et al., 2020).

Value Stream Mapping

Value stream upgrades are a vital step toward lean for most companies, but they must be planned instead of just deploying devices or fixing a problem (Tapping, D. 2002). Six Sigma uses VSM extensively. It is a new tool for lean production. (Vamsi Krishna Jasti et al., 2014). All operations, both those adding value and those not, are included in a value stream map, as well as, the customer, and the client in a closed loop where time is not a factor. In order to produce a certain product or family, it is necessary to create a VS map of the existing assembly process. As the manual is time and date specific, it is imperative that all information be collected simultaneously. Once the present state is complete and the proportional values is factored in, the client-acceptable processing period is the fraction of the total lead time to value, including setup time. Process problems and development targets are plotted on a roadmap to the future. In order to identify the initiatives with the greatest influence on the lead time of the product, value stream maps convey information such as machine utilisation and stock in each operation. A process's ideal future state can be visualised and improved with the help of Value Stream Mapping.

Visual Management

When properly implemented, visual management may help any workplace become more transparent, organized, and productive (Mehta et al., 2020). In his book "The Visible Factory," Grief illustrates this idea with the visual management triangle.

The 5S System

The 5s method is a method for streamlining the management of any operation. There are five steps in the 5s: sort, establish in order or place, shine, systematize, and maintain (Sharma et al., 2018). Each method must be followed to achieve success with a 5s event or for a task to be deemed 5s. Put in arranging and shining are optional based on the organization's needs, although both can be performed utilizing 5s.

Total Productive Maintenance

Total Productive Maintenance (TPM) is an additional aspect of visual management that effectively complements the 5s authoritative structure. As previously mentioned, one of the tenets of 5s is luster, with washing as a measurement. This will eventually teach administrators how to maintain the equipment at their workstations (Rother, M., & Harris, R. 2001). To staff, TPM assigns vital maintenance tasks, such as inspection, cleaning, and lubrication. This frees the specialists or supports staff to focus on more productive maintenance tasks, such as equipment, machine enhancement, updates, and training. Similarly, the goal for safety is zero rates, and the goal for TPM is zero breakdowns (Ahuja et al., 2008). Machine efficiency, availability, operational competency, and Total Equipment Productivity (TEP) are important to Total Productive Maintenance.

Kaizen

Lean manufacturing is frequently discussed in the same context as the notion of kaizen. It's a method of progress that means "transformation for the betterment of all" in Japanese. All lean efforts begin with kaizen. Kaizen is a collaborative strategy for the rapid demolition and rebuilding of an existing method structure with the goal of increasing that structure's effectiveness (Hein, C. 2002). Toyota's JIT production system was built on the tenet of continual improvement known as kaizen. To reduce inefficiencies and improve productivity, this method employs a "try it and see" methodology. This approach is widely used to identify issues and possible solutions (Chiarini et al., 2018).

Poka-Yoke

Poka-Yoke is a Japanese term that means "mistake-proofing" or "error-proofing." It is a methodology for preventing errors or defects by designing processes, systems, or products in a way that makes it difficult or impossible for errors to occur. For this function, Poka-yoke offers an alternative method. Poka is an accidental success, while yoke is the action taken to fix it. Poka-yoke is a simple, low-effort error-proofing design that detects potential problem areas before they become actual ones or halts production to prevent faults if they have already occurred (Chiarin et al., 2018). Reputable poka-yoke systems are straightforward, need little upkeep, can be relied upon 100% of the time, require little in the way of user input, and are tailored to each individual workplace.. Production should be halted or a warning notification given when a poka-yoke detects an issue. If stopping the line in the middle of a process increases the possibility of abnormalities, warning poka-yokes should be applied. A viable poka-yoke must examine one hundred percent of items and provide immediate solution-oriented comments (Forbes et al., 2020).

Takt Time and Cycle Time

The takt time of a product or service is the rate at which it must be manufactured to keep up with demand. To determine this, we divide the available production time by the demand from the market. Cycle time, on the other hand, refers to the time it takes to complete one cycle of a process. It includes both value-added time and non-value-added time. By comparing the takt time to the cycle time, a company can identify areas where it may be falling behind or wasting time. If the cycle time is longer than the takt time, it means that the company is not producing products fast enough to meet customer demand. This can be addressed by reducing the cycle time through process improvements, such as reducing non-value-added time or increasing efficiency. On the other hand, if the cycle time is shorter than the takt time, it may mean that the company is overproducing and wasting resources.

Just-in-Time Production

The goal of JIT production is to have the right quantity of the right product available at the right time. JIT consists of multiple lean tools, such as kanban, heijunka (manufacturing leveling), SMED or rapid machine changeovers, visual management, and a consistent method, which is as advantageous as 5s, TPM, and standardized work (Gadre et al., 2011).

Kanban

Kanban is a visual project management system that originated in Japan and is widely used in the manufacturing industry. The word "Kanban" translates to "signboard" or "billboard" in Japanese.

In a Kanban system, a vision board is used to track the progress of tasks or items through a workflow. The board typically consists of columns representing different stages of the workflow, with each column containing cards representing specific tasks or items. The cards may include information such as the name of the task or item, its priority, and any relevant deadlines or due dates.The main objective of a Kanban system is to optimize the flow of work and minimize waste by limiting the amount of work in progress at any given time. This is achieved by setting limits on the number of cards that can be in each column of the board, and by using the board to visualize any bottlenecks or areas where work is getting stuck. Kanban is used to withdraw components or commodities from a supplier. The provider Kanban contains instructions mandating the shipment of the provider's product (Baudin & Rao 2000).

The amount of Kanban required for individual processes is determined by a combination of a requirement test and a limit analysis (Ladas, C. 2009). Using observable order plans, but ideally with currently booked demand, the requirement test calculates the current daily order for each procedure. The true limit of a given item is revealed by conducting a capacity test on it. Based on this data, the system will determine how many Kanbans are needed.

$$Number\ of\ Kanbans\ = \frac{Daily\ demand \times (Order\ Frequency + Lead\ Time + Safety\ Time)}{Container\ Quantity}$$

Waste has an effect on the delivery strategy, so buffer time is added to make up for it. The number here is also a measure of time in days. A container amount is a predetermined quantity of each item a container can hold. The container size is the component of the kanban condition that is most amenable to adjustment (Abdulmalek et al., 2007).

Kanban additionally necessitates a run line assurance estimation. How to find the breakeven point is as follows:

$$Run\ Line = \frac{Daily\ demand \times Order\ Frequey}{Container\ Size}$$

The largest and smallest stock levels and production lot sizes for each product can be established when the number of kanbans and each production length have been calculated.

$$Maximum\ Inventory = Number\ of\ Kanbans \times Container\ Quantity$$

$$Average\ Inventory = Daily\ Demand(½\ Order\ Frequency + Safety\ Time)$$

$$Lot\ Size = Run\ Line\ Vlue \times Container\ Amount$$

Vatalaro and Taylor advocate conducting a value stream mapping initiative to use these statistics to determine the Kanban implementation method (McCarthy, B. P. 2006).

2.1.6 Limits to the Implementation of Lean:

Even though Lean has received a lot of praise over the years. Both studies conducted within and outside the Lean development have accurately identified the many flaws in Lean logic. The shortcomings of Lean have arisen due to the fragmentation of Lean thinking (Mossman, A. 2009). The greatest emphasis should be on frameworks that enable representatives to analyze situations and encourage workers to use their knowledge to improve unique situations (Weitz et al., 1986). Some scholars have noted that many of its transformation plans need to be inked.

These method advancements and sending tools required to achieve the optimal arrangement are not resting correctly in administration settings.

In addition, there have been trends involving the application of concepts derived from research conducted during the assembly process to the administration section. Lean has been deemed exploitative from a Marxist perspective and places a premium on factory area expertise (Smith, T. 2000). Lean's human analysis facet stems from the fact that the methodology places too little emphasis on social metrics like motivation, respect, and leadership development. There may be various studies on Lean in the wider community but remain important questions that haven't been answered.

2.1.7 Benefits of Using a Lean Approach

The primary benefits of Lean were a reduction in lead times for customers, a reduction in inventory consumption, an increase in the efficiency with which procedures were utilized, and the acquisition of management development skills (Bhatia & Drew 2006).

Various benefits of Lean include achieving profit, improving the overall position, expanding services and quality, and institutionalizing the technique (Sarkar, D. 2015). With Lean implementation, there were several enhancements, including a halving of supply chain network process duration, a 25% increase in client order accuracy, and a 30% reduction in stock from producers. In addition, the use of Lean reduced active impediments. According to Sohal and Egglestone's (1994) research on Australian manufacturers, 75% of businesses reorganized their structures after adopting the Lean methodology. In addition, other advantageous developments included a reduction in the labor force, the recruitment of skilled people, and worker empowerment, which increased their autonomy. Some favorable features include increased worker capability, faster task completion, less customer dissatisfaction, and increased brand devotion (Abou Elnaga & Imran 2014).

Lean is also good for businesses that deal with money. Ries, E. (2011) illustrates a financial service that benefited from Lean. The goal experienced to make it easier for people to get credit so that customer service would be better. The difficulty was the complicated technique with

multiple steps. By eliminating fourteen steps, the duration of the method was shortened by sixty percent or by sixty percent. Frost (2007) looked into a financial institution that reduced the time it took to approve loans by three days, increasing quality and consumer value.

Writers	**Book/Journal**	**Recognized CSF'S**
Petersson et al., (2010)	Lean-Turn deviations into success!	Benefits to the company's bottom line, increased worker capabilities, speedier task completion, lower employee frustration, and happier customers.
Piercy & Rich (2009)	European Journal of Marketing	non-value-added activities.
Melton (2005)	Chemical Engineering Research and Design	Reduced waiting times for customers, Less stuff sitting around doing nothing; better utilization of processes; Enhancing Instructional Leadership,

		Financial gain and less need for do-overs

Table 1: The Upsides of Adopting a Lean Approach

Two benefits of Lean have been cited by multiple authors; the first is that Lean will boost employee morale and competence, and the second is that the standardisation of method or approach will boost productivity. (Eaidgah et al., 2016).

2.1.8 Critical Success Factors

Critical success factors (CSF) are essential to the success of a program; if the factor-related objective is not met, the program will also fail (Fortune & White 2006). The Critical Success Factors (CSFs) are "those few things that must go right to assure success," as defined by Boynton and Zmud (1984). The CSFs are the processes and activities that leadership may control to advance the organization toward its ultimate goals (Oakland, J 2011). There is a great deal of money, risk, and commitment required for each and every advancement (Brockner, J 1992). Hence, it is vital to identify the elements that can influence the approach's success and maintain a safe distance from the risk of loss. If these CSFs are not emphasized, there could be a significant disparity between the success attained and losses of effort, time, and money (Aksorn et al., 2007). For an endeavor to further oorganizationalobjectives and make headway in the marketplace, executives and supervisors must take into account the critical success factors (CSFs).

For Six Sigma project implementation, CSFs refer to the essential components without which the execution has the lowest probability of success. Belhadi, A., & Touriki, F. E. (2016) identified four crucial factors for implementing lean manufacturing in small businesses. Capabilities in these areas include financial resources, skills, management and leadership, and established

company culture.

The following are conditions necessary for the successful adoption of lean, as outlined by Rathje -Scherrer et al. (2009):

- Support for management's dedication and input into employee development;
- Allowing workers to vote on organizational restructuring;
- Transparency in information in minimal objectives;
- And a sign that the poor performance and shaky reliability, in the beginning, have evolved.

Six guidelines are provided for efficient lean utilization, including the following: lean will not succeed without visible management responsibility; create structured environments that promote autonomy, share plans for achieving intermediate lean production targets, and develop norms for managing lean over the long haul; provide limited benefits initially; continuously evaluate progress during Lean efforts (Liutkevičienė et al., 2022).

The executive's role and responsibilities, the employee-boss relationship, cross-cultural communication and training, client-provider ties, venture choice, business interdependence, client-provider ties, project details, organizational structure and goals, training, and data innovation and advancement are all examples (Yayla-Küllü et al., 2015). Stensaker & Langley (2010) state that in order to make a substantial shift in the trajectory, the following elements of success are required: essential financing executives acting as leaders in defining and communicating the shift in sight; a willingness to learn; an openness to tradition; a framework of remembered connections; facts transfer; established procedures; and change management techniques primarily based on implementing lean. Goals and characteristics, complexity and significance, power equilibrium, and resources and competence are all factors that Pedersen and Huniche (2011) believe are critical to a successful implementation.

The following suggestion Founded by Zargun and AlAshaab (2014), CSFs for developing nations are categorized into four basic types: -

Strategy and objectives	Clear target and Common understanding of the direction	Consistent focus on continuous improvement	Credible planning for the campaign
Leadership and management	Top management support and commitment	Identifying the need of lean	Effective motivation and reward system
Human resources	Providing workers with continuous lean education and training	Ability and willing ness to change	Champion and change agenda
External factor	Communication and cooperation	Understanding customer values	Tax laws trade,agreements,political environment

Table 2: Lean CSFs synopsis for emerging economies based on Zargun and Al-Ashaab (2014).

According to Antony et al., (2012), the challenges with most processes include a need for more understanding of lean and a lack of communication and authority. Ingenious preparation, transformative leadership, strong lines of communication, appropriate acknowledgment, the sharing of lessons learned, and, ultimately, a clear goal can help remove the roadblocks to implementation. Executive buy-in, learning, measurement methods, institutional structure (OI), instruments, and workforce-based metrics are the seven pillars of Henderson and Evans' (2000)

lean six sigma implementation model.

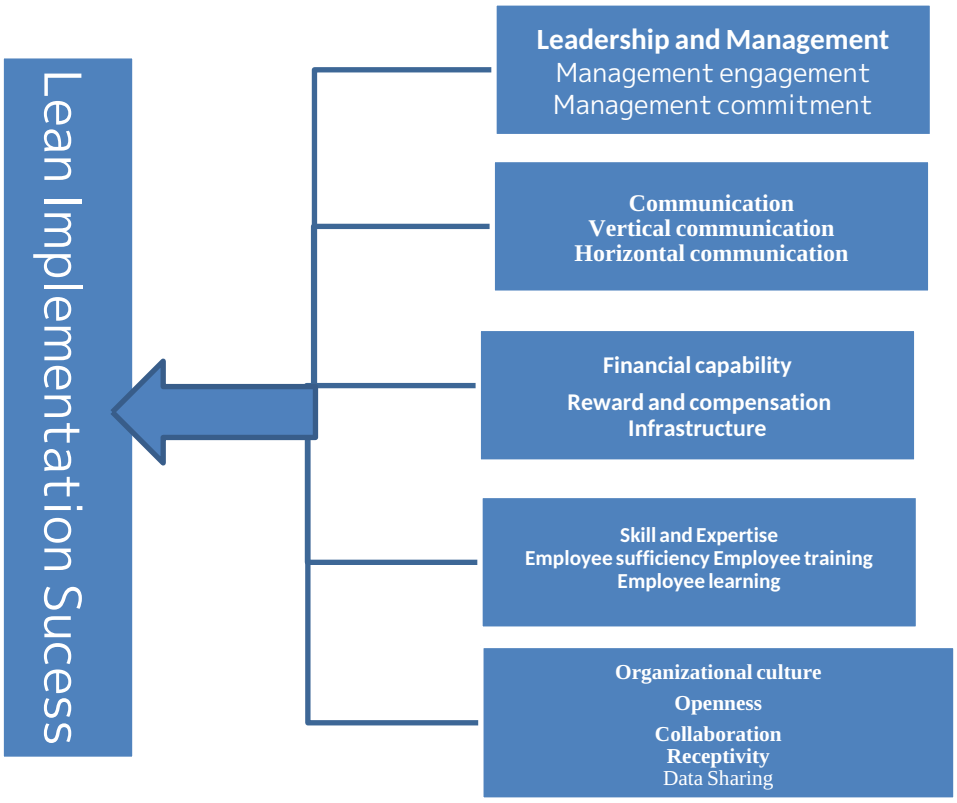

Figure 4: CSFs for achieving lean production success (Modified from Debnath et al., 2023)

Bakken et al., (2006) were recognized for their research on Norwegian and Belgian SMEs conducted as part of the European research project European Regions for Innovative Profitability (EIPP). Consistent with prior studies, there are six proposed essential achievement factors:

- Assuring a robust managerial commitment.
- Evolving with the assistance of employee input
- Focus on fostering initiative-completion motivation.

- Give sufficient time to setting up the organization.
- Develop internal expertise inside the organization.
- Establish a system for evaluating employee performance in the organization.

Factors	Authors
Human Resource	Netland T., Lorenz R., Senoner J. (2020), Kwasnitschka, D., Franke (2021)
Employee Participation and Belief	Shah, R. & Ward, P. T. 2003, Netland, T., Mediavilla, M., and Errasti, A. (2012)
Communication and Administrative Commitment	Åhlström, P., & Karlsson, C. 1996, Lorenz, R., Buess, P., Macuvele, J., Netland, T., and Friedli, T. (2019), Krafcik, J. F. 1988, Fontana, F.; Meboldt, M.; Netland, T. (2017)
Customer Participation	Ferdows, K. & De Meyer, A. 1990, Januszek, S. and Netland, T. (2019), Spear, S. & Bowen, H. K. 1999, Maghazei, O., and Netland, T. (2017)
Provision and Strategy	Bloom, N., Eifert, B., Mahajan, A., McKenzie, D., & Roberts, J. 2011, Sodhi, M., and Wagner S. (2023)
Performance Monitoring	Shook, J. 2010, Dreyer, H., Bjartnes, R., Netland, T., and Strandhagen, J. O. (2008), Krafcik, J. F. 1988, Fontana, F.; Meboldt, M.; Netland, T. (2017)

Process Management	Sugimori, Y., Kusunoki, K., Cho, F. & Uchikawa, S. 1977, Fenner, S. and Netland, T. (2023)

Table 3: Lean Manufacturing CSFs

The table shows the theoretical CSFs for implementing lean practises that the authors developed after conducting a research paper. Critical Success Factors are compiled as a facilitator of lean practice and their interrelationships for a successful implementation. It also includes the methods, standards, and procedures necessary to implement lean throughout the factory.

2.2 Apparel Industry

Several countries, especially those still on the path to economic development, rely heavily on the apparel sector for direct economical support (Lopez-Acevedo & Robertson 2016). Garment sector has played a crucial role in the economic development of numerous nations. This industry plays a crucial role in Bangladesh's economic development regarding employment creation and foreign market expansion. It employs numerous employees, most of whom are women. Companies in the textile business are under a lot of stress because of a worldwide problem and rapid shifts in the retail sector. Competition expansion has driven a greater emphasis on consumer loyalty as a long-term organizational survival strategy (Anabila & Awunyo-Vitor 2013).

At tough work world, environment, companies are vying for survival by competing with one another. Moreover, the textile sector investigates methods and techniques to reduce costs and enhance performance. The textile business has issues, such as cost, delivery time, service, management, etc., intense competitive pressure. This industry has the potential to improve, but certain adjustments are necessary. In spite of the intense competition, the textile business

can expand in many ways by adopting lean principles (Carvalho et al., 2017). Through the use of lean, the textile industry can reduce costs while increasing customer and accessibility by reducing several types of waste in the production process. Customers need high-quality goods delivery. Lean techniques can meet these requirements by reducing lead time, production process duration, and cycle time. Various nations have adopted lean practices in the apparel sector and witnessed tremendous growth (Ferdousi & Ahmed 2009). Because of this activity, their client has become more receptive, efficient, high-quality, and quick to respond. Despite this, lean manufacturing involves, motivates, and develops employee skills through education and a multiskilling program (Ferdousi & Ahmed 2009).

The garment industry is a labor-intensive sector that relies primarily on low technology (Shahidul & Syed Shazali 2011). The textile industry's readymade garment (RMG) section, which constitutes a significant component of Bangladesh's textile industry, is facing increased demand for new styles, shorter manufacturing cycles, and smaller orders due to external problems. Cost and availability may vary, the global business environment of the ready-to-wear garment sector is undergoing a rapid and robust transformation. It is necessary to restructure and reposition the firm (Bullón et al., 2020). In this situation, lean manufacturing aims to reduce lead time and production costs by reducing waste in the production process. Several nations perform exceptionally well in textile production, but others must catch up.

The United States and Bangladesh remain the largest markets for Indian cotton. In the same way, that India has established itself on the world market due to its massive textile industry, Pakistan has also acquired a prominent position on the international stage. Due to increased manufacturing costs, the Pakistani textile sector is currently steady. China is one of the world's biggest suppliers of raw materials and textiles (Atkar et al., 2021). Chinese companies have an edge in the market because of their efficient shipping methods. The importance of the textile sector to the Fijian economy has also been established by research. It is revealed that the textile industry in Fiji formed a vital component of the country's economic framework. The apparel sector contributes to Fiji's economic growth. Rock, M. (2001) claims that competition from

countries with cheap labour costs is a major concern for the UK manufacturing sector as a result of globalization. The textile industry's political concerns are employment, working conditions, and compensation. Outsourcing has contributed to the success of Australia's textile sector. It significantly impacts the Australian economy, accounting for over 10% in production(Shirvanimoghaddam et al., 2020).

As a result of the repeal of the MFA, the global export of textiles increased substantially in 2005 (US$ 275.6 billion with a growth rate of 6.5%; (Bedi & Cororaton 2008). MFA is an agreement between importers and exporters of developed and developing nations on restrictions on textile trade quotas. The quota permits the exporter to ship a predetermined quantity of textiles up to a predetermined limit. The exporter must allocate the quota compensation to local producers (Nordås, H. K. 2004). Bangladesh is currently facing tremendous difficulties. It becomes necessary for Bangladesh to allow other competitors access to the free market.

2.3 Bangladesh's Textile Sector

Bangladesh's primary focused on trade sectors were jute and tea (Sarker, R. 2018). The manufacturing category, especially the apparel sector, has garnered increased attention, according to a similar poll. Since 1980, Bangladesh has increased its textile exports at a faster rate than any other country (Ahmed, N. 2009). The garment sector in Bangladesh is still an outlier among emerging nations that have benefited economies to achieve rapid economic growth spurred by globalization. Bair and Geriffi (2002) conducted a study that relates to the legitimate development of textile firms in Bangladesh. Their analysis portrayed the progression of textile manufacturing in four distinct stages. According to Pharr, S. J., Putnam & Dalton (2000), the primary migration from America and Europe to Japan happened between the 1950s and the mid-1960s. In the 1990s, Bangladesh, Sri Lanka, Pakistan, and Vietnam comprise the fourth stage. When compared to other subcontinental countries like India, Pakistan, and Sri Lanka, Bangladesh remains extremely behind in terms of industrialization (Brass, P. R. (Ed.). 2010). Foreign investors are extremely interested in the Bangladeshi textile industry. Since the late 1970s, Bangladesh's textile sector, which relies solely on exports, has experienced phenomenal growth (Rahman et al., 2017). Bangladesh's primary competitors in the textile

industry include India, Pakistan, Sri Lanka, China, and Vietnam. This competition decreases waste costs, cycle times, and delivery times.

This industry needs to improve in certain areas, such as the lack of variety and diversity in the international market, lengthy lead times, etc (Bruce et al., 2004). Bangladesh has significantly improved its demonstrable capabilities, supplier and provider networks, lowering lead times, sustaining quality, human resources, etc. (Bhutta et al., 2009). Bangladesh has gained substantial interest from developed nations because to its low labor costs and high-quality goods. Regarding fare, the country is gaining a specific position in the fare segment. Its prices increase incrementally and directly. For example, Bangladesh is currently about US $30 million in the 2018-19 monetary period (Rasel et al., 2019). Since it employs over 2.83 million professionals, 92% of whom are women, it can provide significant backing on employment difficulties (NO, T. 2003).

The prosperity of Bangladesh's textile industry was largely determined by its access to European markets before the MFA was abolished in the North American market (Bhandari, A. K. 2021). Reduced labor costs are another key to success. Warner Worldwide (1998) reports that while the cost of producing an item of clothing in Bangladesh is only $0.28 per hour, the equivalent cost in the United States is $11.08. Bangladesh has made a considerable impact on the international economy. Compared to other competitors like Indonesia, Mauritius, and the Dominican Republic, Bangladesh's textile export growth rate is dramatically higher (Islam et al., 2013). Bangladesh sells more than 16% of its RMG to the United States, 65% to European Union states, and 3% to other international destinations (Adnan et al., 2015). The enterprises under review are profoundly affected by the current state of the market. Since many businesses are also exporters, they have little choice but to use lean methods of value creation and product delivery in order to compete in the international marketplace.

3 Methodology

3.1 Methodological Procedure

An investigational flow diagram was thought of as a way to show how the steps of this research were done. The method used in this study and the research flow diagram used in the study is clearly shown in the graph that comes with this study.

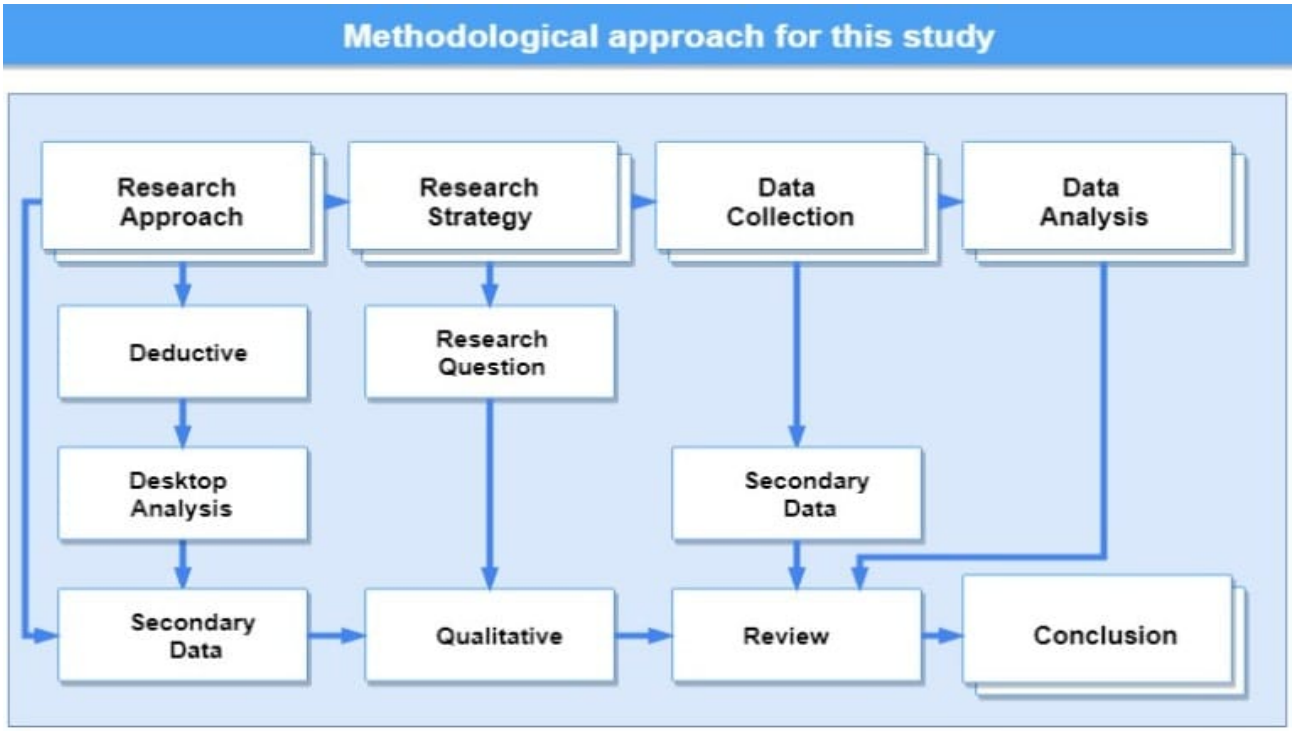

Figure 5: A brief overview of the research design used in this study.

Figure shows how this research has steered progress, plans, procedures, and data collection systems. However, the objectives of this study dictated that the qualitative approach be used for additional data gathering. In order to examine all available open sources, a computer-based investigation was performed. This theory looks at real-world data using qualitative and evocative analysis methods to find possible business areas, etc. There will be three research issues examined in these anecdotal studies. Most of what we know about this idea and this investigation comes from the Internet.

3.1.1 Approach to Research

The primary method of research for this thesis is qualitative research. This research method focuses more on analyzing the data based on what it says than measuring it with numbers. It focuses on an inductive way to develop a hypothesis, just like interpretivism does regarding research (Tsang, E. W. 2013). This research method involves determining answers and their meaning by examining how people act. This is why the structure and methods for collecting data in qualitative research are flexible. This enables the analysts to make adjustments in light of new information gained from the observations or circumstances (Hancock et al., 2001).

3.1.2 Case Study

Case studies can be of two types. The first kind is when a set number of cases are used to come up with a common conclusion. The second point is when the focus is on a single case, and specific goals are set (George, A. L. 2019). This investigation is different based on the first type, which includes a different case (Mills et al., 2009).case study was condensed to allow analysts to focus on the "why," "how," and "what" questions (Atmowardoyo, H. 2018). There has been extensive study on whether or not Bangladesh's implementation of Lean techniques and practises produces the same positive results as those seen in other countries.

3.1.3 Sources of Information

Both first-hand and second-hand data are used in this study. We also used the published archive and other online resources to compile secondary data, which consists of material gleaned from well-known research works such as scholarly articles, books, research documents, theses, and annual reports.

3.1.4 Techniques for Analyzing Data

This study's methodology for analyzing the acquired data relied on deductive research, in which relevant theories are provided to determine the answers to the research questions. In this study, the following research design is used:

Figur 6: Approach to Research (Adapted from Saunders et al. 2009)

A particular kind of data analysis was employed to determine how the case study data differed. There are two primary approaches applied to qualitative data analysis. These are the deductive and inductive techniques, each of which can be approached in several ways.

4 Empirical Study

This chapter will examine the adoption of lean methods and the improvement of the manufacturing process in Bangladesh's textile sectors, as well as the extent to which lean tools are used in these sectors. This chapter will also present a comparative case study of the textile industry in India, the United States, and Bangladesh and report on the benefits of implementing lean principles.

4.1 Case Studies: Lean Management in Bangladesh

In this case study, eight textile companies were used to look at how lean practices work. The companies make many different kinds of clothing. Table 4 has a list of the clothes that different companies make. This table shows the industries that make many ready-made knitted products for men, women, and children. These include woven denim, twill, trousers, woven shirt, skirts, Shirts, sport wears, pants, etc.

NO	Companies Mentioned in the Case Studies	Items Manufactured by the Companies
1.	Ha-meem Group	Hi-Fashion Denim Jeans, Men's Shirts, Dress Pants, Jackets Facility
2.	Beximco Textile Division Limited	All sorts of bottoms & tops in Denim, Twill, Dress pant
3.	Noman Group	yarns, fabrics, home textiles, bed covers, curtains, comforters, quilt covers, denim, and towels
4.	Square Textile	All types of Woven Tops & Bottom
5.	DBL Group	All kinds of headwear of different styles & designs
6.	Viyellatex Group	Woven tops & bottoms for children/ladies/men as well
7.	Epyllion Group	shirts, pants, shorts, jumpers, jackets, vests, Sportswear, sleepwear, ladies' dresses, T-shirts, and fleece items

8.	**Mohammadi Group**	**Men's & Boys' Dress and Casual Shirts, Lady's Blouses**

Table 4: Case study's businesses and what they make (Adapted from Ferdousi, 2009)

All of the companies, in this case, study are foreign partnerships, public limited companies, or limited private corporations registered in accordance with the Bangladesh Companies Act of 1994. The investigation's data analysis reveals that the legal status of various businesses kinds does not affect lean implementation. So, the legal standing of many businesses has a minimal effect on lean techniques. In the present investigation, 56 % of the companies surveyed preferred a team-based, flat organizational structure, and the remaining companies had a tall workforce structure. A collaborative work setting is essential for lean manufacturing methodologies. It contains adaptive, multitalented management personnel who assume high responsibility for work in their regions (Kerzner, H. 2017). Manos, A., & Vincent, C. (Eds.). (2010). *The lean handbook: A guide to the bronze certification body of knowledge*. Quality Press.

In contrast, a realistic organization consists of a chief executive officer and well-designed line managers in pre-existing authority zones. It believes practical specialization along these lines restricts participation in learning and idea-sharing growth (Manos et al., 2010). Businesses that considered this case study adhere to the quality standards of various buyers. Some purchasers employ a specialized international quality management system for internal operations.

The majority of our initial supplies and machinery come from overseas (87%) and locally sourced (55%) respectively. Keeping fewer items in stock is made possible by purchasing from domestic suppliers for both the finished product and the initial supplies. However, certain information must be gathered from foreign sources. One company in this case study is responsible for importing all necessary materials. In comparison, the other options all have lengthier inventory periods because they import between 21% and 98% of their initial products from outside. 55% of enterprises obtain their necessities directly from foreign and domestic

suppliers via a letter of credit, while 33% collect through competitive bidding. A long-term relationship with suppliers is significant to lean practice for total quality control. However, it is revealed that each firm intends to have a long and solid relationship with its providers and suppliers. For advancement, lean generation requires a limited provider base, and a Just-in-Time (JIT) approach is required. JIT framework necessitates the expedient shipment of goods, which is facilitated by a limited provider base. Maintaining good relationships with a wider variety of providers is similarly challenging. As a result of the reviewed firms, however, nearly half have a vast supplier base, sourcing raw materials from 11 to 50 suppliers. This needs to be revised with lean thinking.

Nevertheless, just 21% of organizations could reduce the significant number of suppliers after four years of lean practice (Ferdousi & Ahmed 2009). So, it must be concluded on the effective use of lean in these firms.

4.1.1 The Use of Lean Methods

Lean manufacturing techniques require several types of implementation procedures. The research reveals that the firms utilized many lean tools. All organizations adopted the pull production framework, with 66% utilizing it.

Kanban is an essential component of the lean production paradigm. 66% of the studied firms utilized the Kanban framework, while 33% lacked such a system. Each procedure component is networked with other procedure components, and one-third of companies using Kanban have used digital media, such as a internet-based order structure. The use of compartments or sheets follows this. Some firms employing pull and Just-in-Time, but not Kanban, used spoken instructions instead of Kanban.

Lean methods	**%**
5S	45

Kanban	65
Continuous improvement	74
Just-in-Time	100
Small lot size	100
Pull production systems	100
Application of preventive maintenance	87
Other quality practices	100

Table 5: The various lean techniques implemented by industries and their extent (Adapted from Ferdousi, 2009)

JIT is an integral part of lean manufacturing. One hundred percent of organizations utilize JIT. Kanban is also a crucial component of JIT since it enables the organization to reduce its inventory by efficiently transferring products from one operation to another based on customer demand. This study reveals that all providers are highly reliable in terms of delivery convenience, just as a subsequent delivery of supplies to an organization.

Companies source their equipment and supplies from both domestic and international vendors, with local vendors handling frequent and recurring deliveries. Moreover, the data shows that 76 % of suppliers are associated with the organization as a result of pull systems. The majority of businesses have access to a larger pool of potential suppliers, and 32 % of those businesses use competitive bidding to buy supplies. In the primary instance, sustaining a partnership-based, pull-system connection with numerous providers is difficult. However, soliciting bids for the acquisition of materials demonstrates a helpless relationship with suppliers. While 56% of firms

receive regular shipments from local suppliers who utilize JIT, the remainder have flexible delivery schedules since they use overseas suppliers. (Verghese et al., 2022).

Quantity of suppliers of basic materials	**%**
1-20	30
20-60	40
>60	20

Table 6: Acquisition of basic materials and components: Regional and international suppliers. (Source: Ferdousi, 2009)

Purchasing from a source of basic materials	**%**
Direct acquisition from domestic and international suppliers	56
Tendering	33
Headquarters	11

Table 7: Acquisition of basic materials and components. (Source: Ferdousi, 2009)

In the meantime, some suppliers cannot meet delivery deadlines, indicating a lack of a JIT framework in many organizations, although these firms claim to have a JIT framework. The study identifies the facts associated with the many lean systems adopted by the researching organizations. The data indicates the 77% of claim to have practiced Kaizen, which is continuous improvement and have included quality with a plan, a key lean practice. Quality Control frameworks are present in every firm. In 22% of firms, the qualifying test is administered by the labour force, while the rest organizations have distinct quality control bodies. Based on the query all firms meet the requirement needed for lean maintenance of daily plans (Smith & Hawkins 2004). The more the organization's competence in maintaining production planning, the more impressive the adherence. This study investigated the application of 5S to textile industry research.

Less than fifty per cent of organizations were found to use 5S to some extent. This indicates that the remaining businesses may have a few 5S elements but need a comprehensive understanding of the strategy. However, when firms employ more compercentplicated lean methodologies outside 5S, this may be interpreted as a need for actual lean management. The study reveals that daily, firms are fulfilling their daily output targets. All companies claimed they could meet the daily production plan and always come on time. Using a visual management system, the companies set the desired timetable to determine who was going behind schedule. Their daily production schedules are designed to accommodate equipment breakdowns and unexpected production halts.

Most firms have accurate and routine machine maintenance plans that prevent equipment breakdowns. Lean production necessitates hardware management, which entails the design of machines as production units and installing machines according to the JIT production stream. The rest require a suitable machine and hardware plan except for one business. Due to a lack of room, they needed to properly arrange the gears and equipment, although all the companies had the most recent standard apparatus and system-managing materials. Total Preventative Maintenance (TPM) is a lean machine and equipment support strategy that improves equipment longevity by enabling people to take responsibility for maintenance and improvement tasks (Arslankaya & Atay 2015). Most firms, 89%, have adopted the Complete

Maintenance strategy. Compared to the pre-lean period, all businesses investigated require less time between the conclusion of one production run and the beginning of the next. However, the time lowered varies from organization to organization, ranging from thirty-five minutes to three hours.

4.1.2 Boost of Production

Every organization has successfully reduced the transition time by at least a few degrees. 77% of firms emphasized the employment of small-lot sizes to increase production. Curiously, the understanding of tiny lot estimations diverges from their actual significance. Each business has its own tiny lot estimation significance or measurement. For instance, while one group counted ten items in a small lot, another counted more. There is no standard or universal lot size measurement for all enterprises. These variations in measuring comprehension are also an impediment to lean. Effective lean production requires a just-in-time relationship with customers of finished items. Once a company is in a JIT relationship with its customers. So that it can do the product delivery tasks regularly and without interruption. On time product delivery is possible for 91% of companies. Prior to the implementation of lean, the most significant the whole time from placing an order to delivery was 125 days, and the shortest was 16 days. After that, the most significant process period for lean is 95 days, and the minimum is 12 days.

NO	Companies Mentioned in the Case Studies	Before Lean	After Lean	Reduction (Days)	Reduction (%)
1.	Ha-meem Group	90	75	20	22
2.	Beximco Textile Division Limited	90	60	30	33
3.	Noman Group	37	24	13	35

4.	**Square Textile**	**35**	**20**	**15**	**42**
5.	**DBL Group**	**120**	**90**	**30**	**35**
6.	**Viyellatex Group**	**17**	**12**	**05**	**29**
7.	**Epyllion Group**	**90**	**60**	**30**	**33**
8.	**Mohammadi Group**	**25**	**20**	**05**	**20**

Table 8: Stock turnover rates across industries (Adapted from Ferdousi, 2009)

Reducing the number of raw material inventory days results in less manufacturing waste. The greater the decline in the stock, the greater the rise in garbage elimination. The accompanying table illustrates the number of days on average to reduce from 5 to 30 days across all industries. 55% of the businesses saw a reduction in days from 20% to 30%. The remaining businesses decreased their inventory days by between 33 and 42 percent. The textile and garment sectors can reduce inventory holding time, reducing inventory-related costs.

4.2 Case Studies in Comparing

4.2.1 Case Analysis 1: India

This part was about the Prasad et al. study .'s on how Lean production are used in the textile sector in India (2020). Fabrics are mostly what this leading textile industry makes. Different parts of the organization do the processing, weaving, and dyeing of textiles. The weaving department is the primary focus of this case study., which gets 800,000 meters of orders every month. There are different parts to the weaving section, such as keeping track of the raw materials, weaving, pattern design, size, winding, warping, checking the quality and processing. This case study sees the processing and dying divisions as outside. This company mainly works with two types of yarn: piece-colored and thread-colored yarns, each of which come in solid colors and patterns. Piece-colored material is a woven fabric with the same shade of color.

In-depth analysis of the present state of the company

We must look at the current status mapping before moving on to the following stage. The primary indicator for evaluating the present situation is "takt time". "Takt time" refers to the production pace necessary to satisfy the deadlines set by the client. This phrase is speculative. In this situation, the monthly order is 800,000 meters, translating to 25,000 meters per day. The estimated takt time will be 0.054 minutes per meter, or 3.24 seconds per meter, per order. Current production is 500,000 meters per month, which means it takes 5.18 seconds to produce one meter of fabric. The hours of work is greater than "takt time" by a factor of 1.60, resulting in a shortfall of 300,000 meters per month. The subsequent step identifies where and why time is misused and squandered. The collected information served to organise workplace observations and preventative measures. The figure's circumstances and logical outcomes depict these issues, including the primary contributors to elevated CT. These problems arise from manual delays, machine defects, defective materials, and improper strategies.

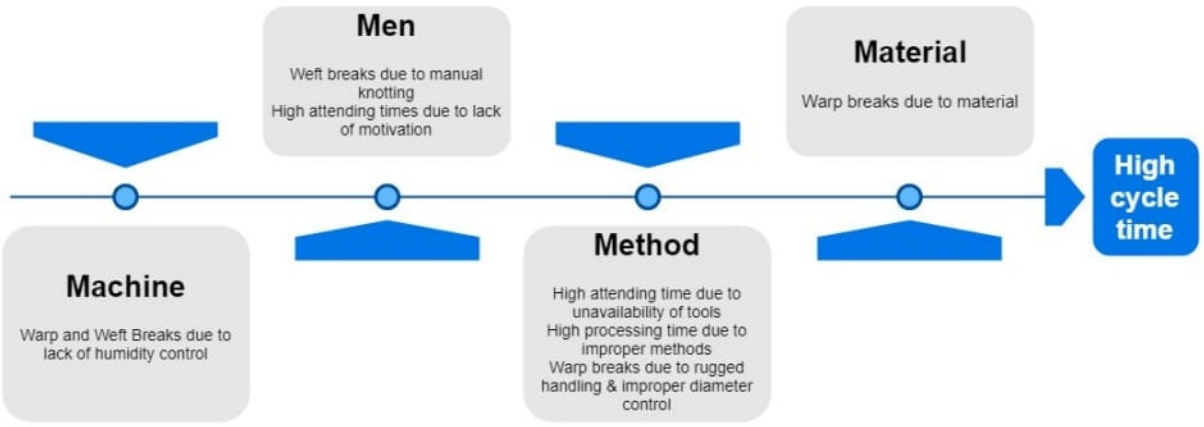

Figure 7: Diagram of causes of excessive cycle time

Warp and weft breaks, a long continuing-to duration, and long planning and execution times are the leading causes of a high CT. This loom's system framework displays an error condition. A yellow light is used, and for weft breaks, a red light is employed for weft breaks. The designated employee should go to the machine and make the necessary adjustments AT the TIME OF light is on. Weft breaks and warp breaks occur for the reasons: bad control of wetness, hand-tying, bad control of diameter, rough handling of good-count threads. The percentage of humidity is essential for weaving and improves yarn quality. Air conditioning is used to maintain optimal humidity in the textile division. To maintain relative humidity between 70 and 80 percent, the inlet and outlet air conditioning must be controlled appropriately.

Nonetheless, the manager in charge of humidity control must have the necessary diagrams or tables to regulate the air intake and exhaust. Variation in relative stickiness leads to filament breaking during the weaving process. Due to this issue, warp breaches occur more frequently. Inadequate moisture and humidity control regulations have caused this issue. In winding division, strings break when the strands are bent and wound around the cones. This problem is tangibly resolved through the use of knots. This phenomenon results in variable thread diameters. When using these cones for weaving, warp, and weft breaks occur. The manual run causes the issue. Maintaining a higher pickup improves the texture of the yarn.

Starch is applied to the yarn to increase its diameter and firmness. Breaks in the warp and weft can occur if the cones are handled roughly during weaving. Fine threads are fragile and susceptible to fracture. Fine threads from the 1960s, 1970s, and 1980s are susceptible to any change in process conditions. Using fine strands frequently results in warp and weft breakage if proper consideration is not given to warping conditions. Each creel on a warping machine has a capacity of 720 cones. There are two types of deformation. Both creels were utilized for split warping, which demanded more than 720 cones.

For continuous warping, however, fewer than 700 cones are required, necessitating an additional creel. During this time creel, the following request is formulated. The warping machine is inert for the additional creel at subsequent request. The secondary creel is left inactive when using the warping machine with the primary creel. Consequently, one creel needs to be more utilized throughout the procedure. The time required to put up the creel is forty minutes. Reed is a tool used to separate individual yarns for sectional warping. Each warping machine contains only one reed. The reed must be replaced throughout split warping, which takes approximately 15 minutes per reed.

Efficiency-boosting policies and procedures

Appropriate lean instruments are required to eliminate various organizational bottlenecks. Five lean methods are identified to combat the problems. The techniques include Kanban, 5S, Poka-yoke, Kaizen, and the Improvement Circle. ***Kaizen*** is a Japanese philosophy that promotes continuous improvement in all aspects of existence. Kaizen, when implemented in the workplace, results in continual improvement throughout the board, from manufacturing upward to the CEO and the factory workers. Kaizen is a daily practice for extension efficiency development. It is a practice that conforms to the working environment, eliminates unnecessary work, and teaches examination using analytical methods. The greatest Kaizen has some criteria:

- Think about the process and outcomes in order to recognize the impact-producing activities.

- Exact thinking about the whole process to avoid creating problems elsewhere in the procedure simultaneously.

Poka-yoke is a method for producing or collecting items with minimal or no defects by employing zero quality control (ZQC). It is a method for faultless procedures. A Poka-yoke framework employs sensors or other devices installed within processing units or machines to detect errors that employees overlook. Poka-yoke structures are utilized to complete two essential components of ZQC, namely, 100 percent investigation and rapid response. Poka-yoke systems are utilized in the preliminary inspection to detect errors before production creates a defective product. Utilizing one of the following methodologies, a Poka-yoke framework regulates the manufacturing and eliminates defective products.

- When a problem is found, the control system stops the machine right away.
- When a mistake is detected, the machine will immediately stop and an alert will be sent to the management.

Human resource managers are the backbone of the quality circle and to regard as essential factors in enhancing product quality and profitability. It implies the enhancement of the individual's aptitudes, skills, confidence, and originality through comprehensive instruction, preparation, work comprehension, and assistance. The quality circle concept has three essential characteristics, such as being a form of participative management, a Personnel development procedure, and a system of critical thinking. A good circle is made up of volunteers working together to improve an area. They may be related to quality, profitability, well-being, work structure, process flow, a control element, workplace and culture.

Kanban is a system for keeping track of work. Kanban is used as a part-draw method, which needs to be planned. It entails producing and the daily scheduled actions required to run the production procedure. Kanban reduces inventory, enhances workflow, anticipates overproduction, manages space at the operational level and makes visual planning and procedure management. Using various lean tools collaboratively increases the overall production capacity of an organization.

System-wide enhancements

Carton containers have replaced sacks for transporting structures from the spinning section. This reduces quality distortion, thereby enhancing the nature of the textile. Color tagging the finished shafts and cones is shown to improve the procedure's flow flexibility. Red for more than 10,000 meters, yellow for between 1,000 and 10,000 meters, and green for less than 250 meters.

This increases the manufacturing procedure's adaptability. Orders greater than 10,000 meters can be assigned a higher priority. When navigating cones and beams, employees would be more vigilant. Void beams are placed in an environment from which they are typically retrievable. During solitary winding, only one creel is utilized. Cones can be matched with the dormant creel for the next phase. As a result, the deformation process produces more material and the creel spends less time idle. In addition to professional advice, it is necessary to identify and note the shortcomings of tools like cutting instruments and implements that cause warping. Another important suggestion is to change all machines from one to two reeds, allowing for division distortion and weaving of complex patterns. It is possible to skip the time needed to prepare for taking out and shifting reed.This saves approximately ten minutes per reed-changing procedure. (Saleeshya et al., 2012) As shown in Figure, the delay in the drawing procedure is due to the ongoing collation of the strands in the creel. Due to this continual aggregation, the adjacent threads are parallel. This needs to be clarified for the drawing process. As demonstrated in Figure, collation is conducted to distinguish adjacent strands. This creel collation distorts the yarn in a traversed manner.

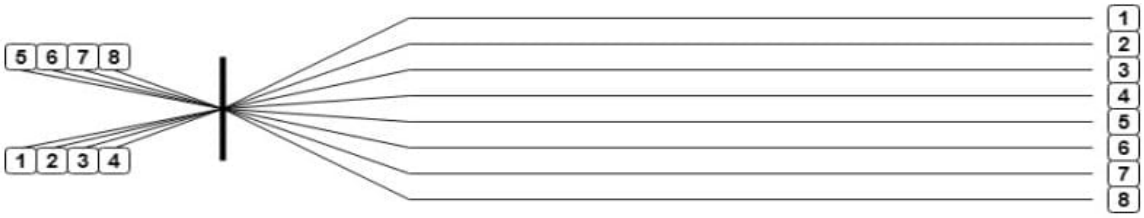

Figure 8: Old creeling Order. (Modified from Saleeshya et al., 2012)

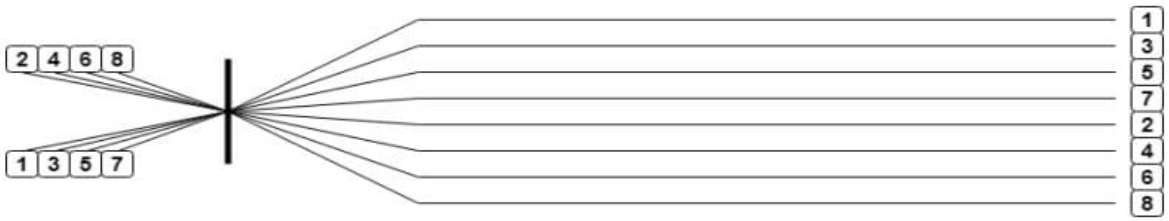

Figure 9: New creeling Order. (Modified from Saleeshya et al., 2012)

4.2.2 Case Study 2: US

Numerous U.S. textile industries have sought to improve their assembly processes to compete with foreign manufacturers more quickly to remain competitive. This case study identifies specific lean tools and standards. This case study examined the use of lean production in the textile industry. A model for implementing lean techniques and standards in the textile industry is presented (Maia et al., 2013).

National Textiles of the U.S. initiated its lean assembling execution process in 2004 with the assistance of North Carolina State University's (NCSU) Industrial Extension Service (IES) (IES). The company sought to reduce waste and increase profitability (NCSU IES, 2007). Their initial lean implementation yielded outstanding results, including a 30% increase in profitability and a 40% reduction in costs for that production unit (Zare et al., 2016). The project implemented techniques such as 5s and principal workflow. The purpose of the second lean projection was to enhance the quantity and flow between the two processes. To achieve this objective, the project directed 5s exercises, determined process duration and takt time, and conducted a value stream mapping (VSM) practice.

Lean tool	Portion of Organizations Evaluated
5s	100
Visual Management	90.8
Six Sigma	54.5
VSM	81
Kanban	27.5
TPM	45.5
Kaizen	62.5

Table 9: Various lean methods implemented by organisations are examined.

Ten organizations utilized visual administration and 5s. Nine of the organizations had implemented value stream mapping. The 5s was frequently cited as one of the most prominent lean techniques implemented. The following obstacles to implementing lean production were cited:

- Employees on the floor are reticent to recommend improvements.
- Lack of connection between business skill development.
- Because employees are not fluent in English, linguistic training is necessary.
- Belief that since textile industry machinery represent such a substantial investment, they must operate continuously.

Organizational culture shift was the most investigated interference. Organizations were required to commence their activities with the utmost administrative responsibility. Most lean activities should have involved the floor staff and should have been carried out effectively. Lean

activities were selected for early success (Scherrer-Rathje et al., 2009). Among the mentioned benefits of implementing lean methods are the following:

- Reduces the product's complexity
- Reduces inventory, one company's inventory was cut in half.
- Reduces the quantity of basic materials.
- Reduces completed product inventory.
- It speeds up the changing process.
- More output was generated. After the switch to 5s, output jumped by 15% in just one month.

A brief description of the case studies of three companies in the United States follows:

Structure of a Case A – 5S

The company is able to provide a comprehensive range of products, including fabrics and denim by spinning, cutting, distorting, and weaving section. The company introduced the 5s concept to its employees with the assistance of an industrial development-focused advisory agency. In a certain section of industries facilities, operations were generating several times the waste than intended. The initial incident halted production of the division for three days. The organisation halted generations in the area to demonstrate their commitment to the event, as they required everyone to pay attention. There were approximately 30 people at the event, which was attended by every employee in the region. The first stage was to organise the clutter on the tables, workstations, and equipment by removing non-essential items and unnecessary equipment. Red-labeling was employed to distinguish such goods to the standard production unit. Using labels and indicators, the next step was to designate locations and points of confinement for hardware and product inventory. Indicators, such as identifying proof signs and lines, were also installed to demarcate pathways and the various stock areas. For instance, stock areas for idle shafts were divided by outlines on the surface, signaling to the specialist where these items were to be stored and maximizing the number of propellers that might be

held.(George et al., 2011).

Equipment and instruments that would be utilised frequently all over the workweek were positioned and stowed close to their intended use. This facilitates the retrieval of these items when necessary. Priority number one for the administration as they departed this 5s event was cleaning and organising the floor. The work area and machinery were thoroughly cleaned to eliminate waste, grease, and oil. The next step was to ensure that working procedures were up to par and that everyone in the region was trained in 5s and understood the organization's objectives. The fundamental procedures were documented and readily available to any employee who inquired about their work. The organisation utilised a 5s audit framework for enhancements in production. After the three-day event, a weekly meeting was convened to support 5s, which was an important step. These gatherings produced recommendations for enhancing the procedure and working environment for the participants. In the past, employees were reluctant to offer their opinions. However, once the executives offered a few words of consolation, the employees and floor workers were able to freely express their thoughts and ideas.

Since the start of the meeting, over 30 initiatives for growth have been recommended and approved. The managers prioritised these recommendations. Activities may be under review, drafted, approved, or concluded. As a result of the 5s programme, the organization's waste reduction has exceeded its goals and expectations. Subsequently, the waste reduction was minimal and took over half a year to manifest. A further benefit of the weekly 5s meeting was that employees gained a greater understanding of the impact of waste. The administration initiated efforts to minimise waste on the premises. The organisation intends to continue the employee gatherings. Due to the moderate weather, however, the frequency of meetings has been reduced to every two weeks. This company is pleased with the success of 5s in that division and may wish to implement the program in other areas of the plant (Hodge et al., 2011).

Structure of a Case B – 5S

This company makes a lot of different kinds of yarn that can be used in goods. The desire for efficient execution at this organisation originated from the corporate level. After two managers attended a 5s course, the organisation initially implemented 5s in its facilities. It utilised the support of a regional specialist throughout the development of the programme. The organisation began by establishing a 5s initialization and training programme, which was then transferred from one facility to another. The 5s groups were formed at the facilities, but the ultimate objective is to train every representative in 5s. The majority of the organization's facilities are computerized with a few employees. So, people couldn't be taken away from their jobs for a very long time to finish 5s. An important aspect was ownership; that had to take responsibility for the project, and that person became the lean group's facilitator. The organisation produced 5s using the same resources as organisation A. Organization B only temporarily removed employees from their duties and relocated them. The 5s coordinator presented the 5s structure. However, the initiative was the responsibility of the group's facilitator (George et al., 2011).

This case involves the application of 5s in a specific facility, which, unlike the other cases, was not carried out in an area responsible for product processing but rather in a machine room. This case exemplifies further how a 5s programme can be implemented anywhere. The degree to which the 5s facilitator in this project had implemented the 5s system in this company's machine room was astonishing. Company B failed to use the 5s programme format. Instead, they taught their employees about 5s in a short classroom setting and gave them the materials they needed.

The 5s supervisor said that choosing the right gathering and instructor was important for this 5s implementation setting to work. The facilitator was usually a boss or an expert in the project's field. The teams needed the right mix of people, some of whom worked in the subject area and some of whom didn't. Sometimes, people who didn't work in the subject area could offer new and different points of view. The 5s initiatives for organisation B have adopted a "piecemeal" approach, in which only a small amount is completed at a time. The meticulous labelling of each component was what made the machine room at this particular organisation so remarkable. In the machine room, each cabinet and cupboard was marked with a picture and a short

explanation of the machine it held. On each part of the cabinet, there was a representation and a short account of what it held. On the top of every case was a list of all the parts, including what they were, where they were, and how to put them back in order. The tops of the shelves were not flat, but sloped, to keep them clear of things. Thus, anything placed on top would slide off. There are pegs on the wall for hanging various machine-required belts. So that the right belt could be placed on the right hook, outline drawings of the belts were put up on the ceilings along with accounts of what was in each belt. By paying for numerous dollars in fives, the group saves $100,000. The 5S initiative in the equipment area of this particular study has made it easy to find all parts and devices. Before, people would ask for machine parts that were already in stock. The person in charge of this 5s project in the equipment area thought that the company would save more than $42,000 in the device and part repair costs the following year. (George et al., 2011).

Structure of a Case C – Value stream mapping

Organization C is a modest textile industry with fewer than 150 employees that produces knit and woven fabrics. Organisation C planned a three-day, eight-hour-per-day training on value stream mapping (VSM). The event was attended by seven managers and employees of the organization, including the Chief Financial Officer (CFO), plant engineer, plant manager, production manager, and customer service manager. The movement was supported by lean specialists from the consulting group, from whom the organization seeks training assistance for its primary lean program implementations.

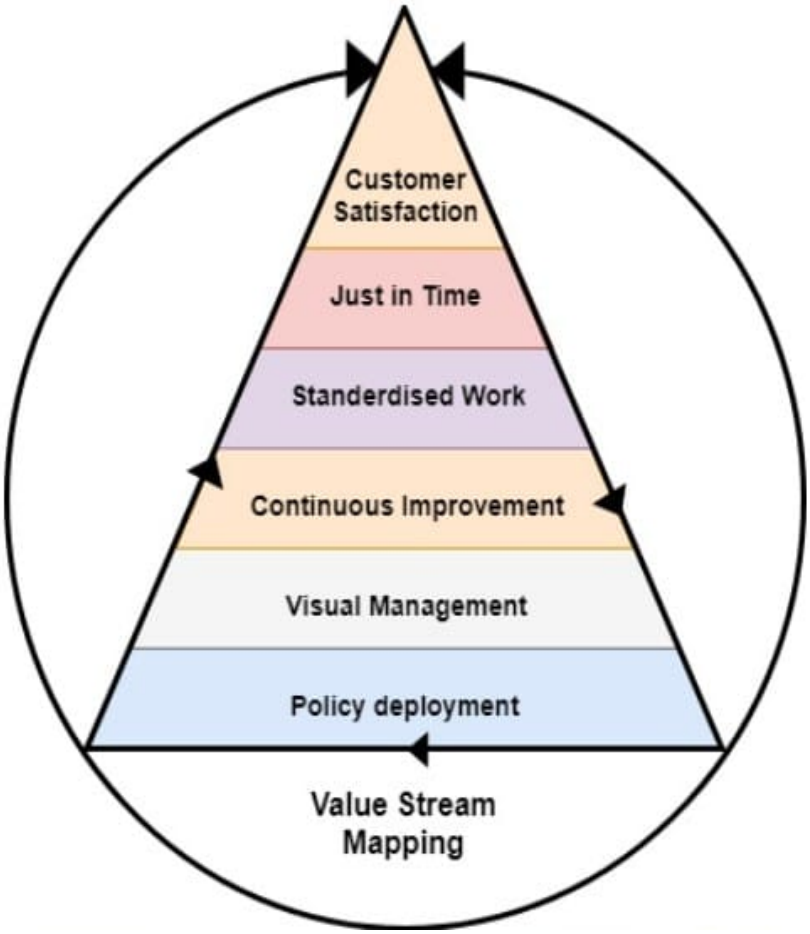

Figure 10: Lean implementation paradigm.

During the training session, the trainer briefly explained lean assembly and the types of waste in terms of value-added and non-value-added. The instruction additionally presented the team the state map of a made-up business and talked about why value stream mapping is important. After that, the group started to work on the current state map of the organization. The first step was to decide what product or set should be mapped. The first group of items chosen was made in large quantities. subsequently the team decided on an item, it was decided that the takt would rest on a customer's guess of 4 weeks. It takes for the machine to complete a cycle, and how often it is used. Then, every step in the data stream was written down so that everyone on

the team could see and agree with it, along with every step reported in the data stream. Then everyone agreed to the map's material and data flow. Then, the guide showed the teams how to divide the share amount into the takt to get the number of days between each step of production.

The production lead time was then found by adding up the lead times for each process. The value-added time was found by adding up each step's process or cycle times. The percent value added was found by dividing the time spent adding value by the time it took to make the product. The amount of value that Organization C added to this product was less than 1%. The team came up with was to reduce the amount of desk work in production control.

4.2.3 Case Study 3: Mother Colour Ltd

The case study highlights the successful implementation of Lean principles in the textile industry in Bangladesh, specifically Mother Colour Ltd. The company's commitment to Lean, employee involvement, waste reduction efforts, and continuous improvement led to enhanced productivity, reduced costs, improved quality, and increased employee engagement. By embracing Lean practices, textile companies in Bangladesh can remain competitive in the global market and drive sustainable growth in the industry. Mother Colour Ltd, founded in 2007, is outfitted with state-of-the-art machinery, including Knitting, Dyeing, and Garmenting backward processes, and a competent design and development staff. European retail giants like H&M, INDITEX, and PULL & BEAR trust Mother Colour as a trusted supplier. The production output is 40 million RMGs per year, plus an additional 35 tonnes of fabric production capability per day as a safety net. In their mode of manufacturing, Mother Colour employs approximately 15000 individuals.

This section contains data acquired directly from the field, making it primary or firsthand information. From January to August 2017, the organization practiced six sigma using Lean. After identifying the waste section's causes, they solved each issue that caused the skipped stitch, oil, and unclean patches. Respective numbers represent these problems' causes and

corresponding solutions.

Drop of Oil

An *oil spot* is a common defect that can occur on fabrics during various stages of textile processing. It appears as a dark or discolored area on the fabric surface, resulting from the deposition of oil or lubricants used in machinery during spinning, weaving, or finishing processes. These spots can be challenging to remove and may affect the aesthetic appeal and quality of the fabric. Manufacturers often implement quality control measures to minimize the occurrence of oil spots, such as ensuring proper lubrication practices and regular machine maintenance.

Cause and Effect

- The sewing machine and work table are not clean
- Failure to the stated cleaning procedure
- Running body left on an idle Or underused machine
- Failure to comply with the defined covering procedure during a maintenance
- Oil seal has no defined replacement interval.

Solution

- Each sewing machine's oil seal needs to be inspected within 45 days.
- Provide instructions for cleaning the sewing machine and the work surface
- Create cleaning instructions for the Sewing Machine.
- Develop guidelines for concealing the body of clothing during maintenance.

Dirty Spot

A dirty spot refers to an area on a fabric that is visibly soiled or stained. This defect can occur due to various reasons, such as inadequate cleaning of machinery or equipment, improper handling during manufacturing or transportation, or accidental spills. Dirty spots can range from minor localized stains to larger areas of discoloration, and they can significantly impact the fabric's visual appeal and market value. Manufacturers usually strive to maintain cleanliness throughout production and implement quality control measures to detect and address dirty spots before the fabric reaches the market.

Cause and Effect

- Uncovered cutting input stock
- A machine with a running body that hasn't been utilised in a while
- Usage of Filthy Shoes on the Floor
- Lack of Timely Floor Cleaning
- Consuming a meal or tiffin at work
- Hands not adequately washed
- The input/output print embroidery body is inadequately covered.
- Uncovered running products at the conclusion of the day

Solution

- Develop protected cutting technique
- covered running products during operator machine cleaning
- Isolate the idle machine from the active machine.
- Create instructions for using shoes on floor
- Provide cleaning instructions for the floor

Skip Stitch

Skip stitching is a sewing defect that can occur when stitching fabric layers together during garment production. It refers to the unintentional absence of one or more stitches in a continuous sewing line. This defect can result from faulty sewing machines, incorrect thread tension, or operator errors. Skip stitches can weaken the seam strength, affect the overall structural integrity of the garment, and lead to potential unraveling or fraying. Manufacturers implement quality control checks to detect and rectify skip stitches during production to ensure the finished garments' durability and quality.

Cause and Effect

- Absence of stated speed for fabric type and needle size
- Incorrect hook and needle adjustment
- Procedure and Accountability for Needle Setting are not specified.
- The selection process, criteria, and responsibility for needles are not described
- Needle bend
- Procedure and Accountability for Setting Thread Tension are not stated

Solutions

- Describe needle life and the relationship between needle size and cloth type.
- Validation after hook adjustment with needle
- Establish Standard Operating Procedures for Needle Setting and train operators for Needle Setting
- Standard Operating Procedures for Needle Selection and Accountability

Addressing these defects and maintaining high-quality standards is essential in the textile industry to meet customer expectations, minimize product rejections, and uphold the reputation of manufacturers and exporters in Bangladesh. Quality control measures, proper maintenance of machinery, regular training of workers, and adherence to standardized production processes are some strategies employed to minimize the occurrence of oil spots,

dirty spots, and skip stitches in textiles.

5 Analysis of the data and subsequent discussion

Using different lean practices is one way to determine an organization's leanness. Each company in the case studies said that their textile plants generally used lean methods. Studies show that the reviewed companies have different ideas about what it means to be lean. The organizations changed lean to fit their culture and resources, which led to many different ways of explaining what lean is. In recent years, India has emerged as one of the leading textile manufacturers globally. To remain competitive, Indian textile companies have embraced lean practices. One significant challenge faced by Indian textile manufacturers is the complex and fragmented supply chain. Lean principles such as Just-in-Time (JIT) production, value stream mapping, and Kanban systems have been employed to streamline operations and reduce inventory levels. Furthermore, Kaizen events and continuous improvement initiatives have been implemented to foster a culture of continuous learning and process optimization.

The US textile industry has faced numerous challenges due to rising labor costs and competition from low-cost countries. Lean practices have been instrumental in revitalizing the industry and enhancing its competitiveness. US textile companies have implemented strategies such as Total Productive Maintenance (TPM), 5S workplace organization, and Six Sigma methodologies. These practices have not only improved operational efficiency but also reduced defects, increased customer satisfaction, and improved employee engagement. Moreover, implementing lean practices has facilitated the adoption of advanced technologies, such as automation and robotics, to enhance productivity further and reduce costs.

Bangladesh has experienced remarkable growth in its textile industry over the past few decades. However, the industry still faces labor productivity, quality control, and lead time management challenges. Lean practices have been adopted in many Bangladeshi textile companies to address these issues. Single-Minute Exchange of Die (SMED), cellular

manufacturing, and standardized work have been implemented to reduce setup times, enhance flexibility, and improve overall efficiency. Additionally, initiatives like Lean Six Sigma have been introduced to tackle defects and variations in production processes, improving quality control.

While implementing lean practices in the textile industry is beneficial across the board, variations exist in their effectiveness due to the unique socio-economic contexts of each country. India's focus on supply chain optimization aligns with its fragmented industry structure, allowing companies to reduce lead times and enhance responsiveness. The US's emphasis on advanced technologies and automation capitalizes on its higher labor costs, driving productivity improvements. Bangladesh's adoption of lean practices addresses the need for enhanced productivity and quality control in its rapidly expanding textile sector. Lean practices have proven instrumental in transforming the textile industry across India, the US, and Bangladesh. Each country's unique challenges and strategies have shaped its approaches to lean implementation. By comparing these cases, we have gained valuable insights into lean practices' diverse applications and effectiveness in different contexts. As the textile industry evolves, adopting lean practices will remain crucial for companies to remain competitive, improve efficiency, and meet customer expectations.

5.1 The extent of Lean Manufacturing Methods

Getting lean work done well depends on different things and to different degrees. The study found that some textile companies started using lean methods in their plants when they started making things. On the other hand, others started lean execution a few years after the company was founded. The findings suggest at lowering costs, increasing profits, the success of lean usage depends not on how long it has been used but on how well it is used. No matter their legal status, whether it was private, a worldwide joint venture, or public, the organizations got better at being efficient and getting things done. In this way, the legal status of an organization has no immediate effect on how well it makes things or on essential projects like lean generation. Most organizations were set up around groups, while the rest were around functions. This differs from the common idea that an organization framework is essential for using lean or doing any

progress activity well. Even though the example shows that organizations have different hierarchical structures is fine for lean performance. It also shows that the organization's top management needs to learn how a good structure limits flexibility.

Even though they get the same results as group-based organizations, this keeps changing how power is distributed from functional to group-based. When done right, lean gives many ways to use visual management to communicate rules and show the size of stock, the status of a process, and how work is being done. A supplier or provider base is one of the most critical signs of lean production. Most industries rely on many providers instead of the basics of lean business. Even though most industries want to keep their relationships with providers for a long time, it is hard to keep extended, stable relationships with many such providers. When there are many providers, and the number does not go down then need strategy to cut down on the number of providers. So, recognize more benefits, such as a long-term relationship with providers based on sharing risks, costs, and information. Two essential lean practices are "just in time" and "pull production framework."

Main idea behind JIT is a force approach, in which the steps of production process are linked to control by the steps of the next level. A Kanban structure usually moves the signal from one level to the next because a service or product needs to be done. All the companies had a "Just in time" and "pull" system for making things, but only some used Kanban. Instead of the Kanban, organizations that did not have it used verbal instructions. This verbal direction could lead to noise, instability, and a chance of misunderstanding. A key part of lean production is a framework called "Just-in-time. However, importing materials does not fit under "just in time" because JIT means getting the right amount of production. The textile industries in Bangladesh were found to use a "just-in-time" system and get their raw materials from nearby suppliers. Because the groups had to get materials from other countries, the delivery time was two months. This made it possible for industries to make items available for the JIT process. Kaizen is one of the most important parts of lean. Most companies have been using Kaizen, which stands for "continuous improvement," how their products are put together. To measure how well the improvement process was going, the organizations gave recommendations like worker participation, rewards for workers, free critical thinking, easy administrative input to the

workforce, etc. The organizations were very motivated and put the suggestions into action in order to keep getting better.

However, in Bangladesh's current stable social and political situation, textile industries can always meet the schedule, which was not the case in previous years. Also, the organizations ran into problems with transportation, traffic jams, and so on, which sometimes slowed down the delivery process. Sticking to the planned schedule is not so hard now that things are as they are. This includes the layout of machines in production units and how they are set up. All but one industry had a good initiative for how to set up equipment in a U or V shape. By reducing the amount of space needed for production, an effective hardware plan cuts down on the need for plant facilities. Material handling frameworks have always been updated and modern in industries. From the case study, we can see that all organizations in the US and India use 5S, but less than half of the organizations in Bangladesh do. However, 5S is a fast and simple tool for improving quality in a way that never stops. When the companies studied, use other, more complicated lean methods but not 5S, it shows that they are not using lean. Most of the time, if a company has enough knowledge and experience with lean techniques, they will start with simple tools and see how they work before moving on to more complicated ones. Companies use 5S to make sure their workplaces are perfect and work well. This shows why companies need a deep understanding of lean-related techniques to ensure success.

Bangladesh's textile industries that have been looked at have small amount of device swaps times of 25 minutes to 3.5 hours, which is a big deal. All of the groups stressed the importance of using small lot sizes. However, the groups do not agree on a basic definition of "lot size." Even though a small lot means a single-piece stream in lean manufacturing. In the Bangladeshi company that was looked into, a small. As many pieces, this realignment cut the size of the organizations' stocks and overproduction by a lot. Smaller lot sizes made it easier for companies to spot bad items than in the past. Every lean business needs a framework for managing information to link its practices. The businesses in Bangladesh were using the software that their clients approved. This is because companies bought those programs before they started using Lean. The business were not willing to change because substitution is expensive. Lean is a structure for responding to customer needs that emphasizes reducing delivery time. Companies

are said to have used some lean tools, like JIT, Kaizen, Kanban, etc., to make sure they get products to customers on time.

From the data, companies could shorten the time it takes from receiving an order to sending it out if they used these tools. This means that businesses can improve more from a full implementation of lean. The businesses received assistance and training from consultancy companies, sometimes known as specialists, to apply lean practices. The major objectives of the training are to teach employees how to do a variety of tasks, develop their managerial skills, and other things. There needs to be a complete training program and a mechanism to put it into action that meets the demands of each organization, enabling all of it to work and to try to achieve durable improvements.

5.2 Considerations in Lean Implementation

The lean production system in the apparel sectors under consideration is influenced by a variety of factors. The current debate distinguished between a few factors that supported lean implementation that limited its use. However, the positive qualities vary from company to organization based on its culture and available resources, such as administrative commitment, technical assistance-trained personnel, etc. The supporting and opposing factors are listed below. Many elements aided the companies in their pursuit of lean execution.

Organizations review training as the most crucial supporting aspect. The Indian and American textile industries examined received training from independent experts and specialist staff. In Bangladesh, it is BGMEA, the umbrella body that depends on the general well-being of textile processing. Training is a fundamental requirement for implementing lean and efficiently utilizing lean systems. Training that focuses mainly on on-the-job training, with an emphasis on hypothetical training in completing various tasks.

- A sensible consciousness of the lean framework among the administrative personnel of the organizations allowed for continuing lean implementation. This indicates that planning has to perform an excellent job of increasing awareness.

- Management's commitment is an additional important factor in favor of lean deployment. In their respective firms, the best administrative responsibility and assistance is an additional crucial empowering aspect.
- For particular industries, client feedback was an additional impetus for implementing a lean architecture. Large customers in Bangladesh, mostly foreign export customers, demanded higher quality goods at a reasonable price discount compared to the most prominent competitors in South and Southeast Asia, including China.
- Good staff attitudes had a significant role in lean execution. As a result of the employees' positive outlook, they did not object to its implementation in the industries. For this participation, organizations with progressive work environments based on groups.

In general, the textile industry found various hurdles when implementing lean. However, in addition to the impediments outlined in the preceding section, the aforementioned supporting factors entail many additional obstacles the organizations face. In this transition program, most investigated textile businesses confront resistance from various organizational sections. In Bangladesh, employee conflict is one of the most inhibiting factors. 2% of the assessed industries in Bangladesh met no resistance; middle administrations and lower-level supervisors mostly opposed the remaining firms.

A lack of adequate understanding of the new framework caused this barrier. Occasionally, external competitors get trained employees to leave their businesses by offering enticing benefits and unique capabilities. The firms require a minimum of trained personnel to generate and sustain innovative ideas. Traffic and transportation problems are essential obstacles to lean manufacturing, as JIT is primarily dependent on them. Who has an operational transportation system and no automobile problems? Companies that utilize the third-party vehicular system have vehicle-related concerns. Bangladeshi organizations regarding a port for foreign exports have raised concerns. Those who employ city highways for distribution confront excessive traffic and, as a result, challenging delivery times.

Although most companies have their power generators, the power supply issue in Bangladesh remains a serious concern. Half of the assessed businesses in Bangladesh experienced the unfavorable effects of intense supply concerns, including decreased efficiency and increased

costs. Several delegates' insufficient knowledge led to erroneous judgments and errors on lean's vital necessity. The cause of this issue is a need for more training. The following graph illustrates the overall benefits, key impediments, and supporting elements of Bangladesh's textile industry.

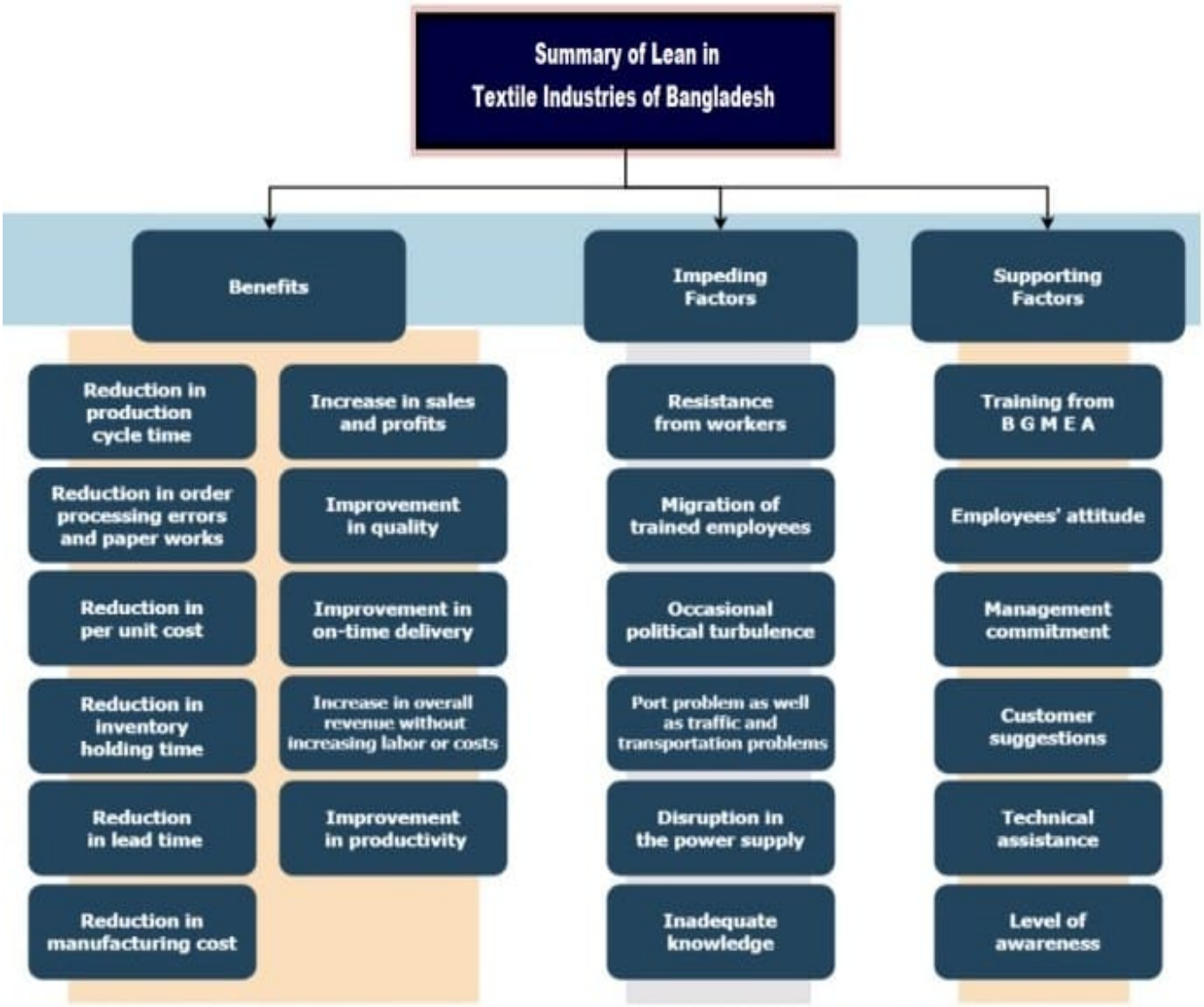

Figure 11: Advantages, barriers, and enablers of lean implementation in Bangladeshi organizations. (Modified from Khalid & Khan, 2022)

5.3 Resulting advantages from adopting Lean approach

Investigated textile businesses in Bangladesh wants to incorporate lean production into their operations for its benefits. The firms studied derived benefits from lean approaches, including higher Prosperity and revenue, fewer changing errors, more digital work, and lower labor expenses. In contrast to pre-lean period, overall costs were decreased by increasing the number of things produced with the same amount of labor while decreasing inventory. The research indicates that firms' profitability and output have increased. High lead times demonstrate the inefficiency production system. The more significant reduction in length of a process, the greater the organization's gains in terms of increased unit production. This reduction in cycle time resulted in an increase in client loyalty due to the expedited delivery and also opened the door to accept consumers. Diagram below depicts the improved circumstance that lean method reduces purchase-to-ship duration.

Figure 12: purchase-to-ship client service (Mother colour Ltd.)

Textile business improved significantly by reducing the number of lengthy stock stretches. This was made possible by increasing communication, developing supplier relationships, educating suppliers, implementing JIT delivery of finished products, and employing particular databases and feedback systems. In a competitive market, sustaining a high level of product quality is essential. The survey revealed that most firms significantly increased quality while decreasing waste and expenses.

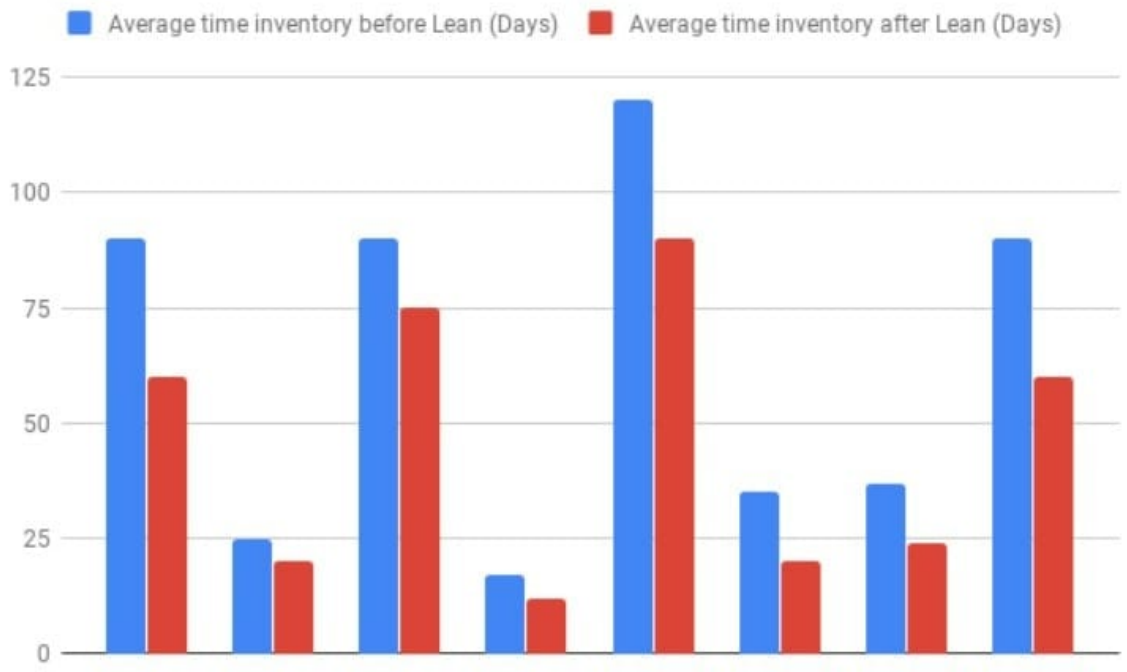

Figure 13: Inventory days before and after lean (Mother colour Ltd).

The primary objective of lean production is to eliminate several types of waste from the production process. Each company reduced waste resulting from overproduction by implementing a make-to-order strategy, which means that product production will commence

when a client orders. In addition, the firms reduced their inventory using the Just-in-time delivery system, trained their staff, and developed strong relationships with their suppliers. The outcome indicated a significant reduction in all types of trash. Nonetheless, there is still the possibility of further decrease increases.

By utilizing six sigma (6σ) and lean to reduce the manufacturing waste of skip stitches, oil spots, and filthy spots from January to August of 2017, Mother color Ltd. developed a solution for every problem caused by skip stitches, oil, and dirty spot. Applying these solutions to the problems improves the reduction of waste caused by unclean spots, oily areas, and skipped stitches, reducing waste caused by oil, dirty spots, and skipped stitches.

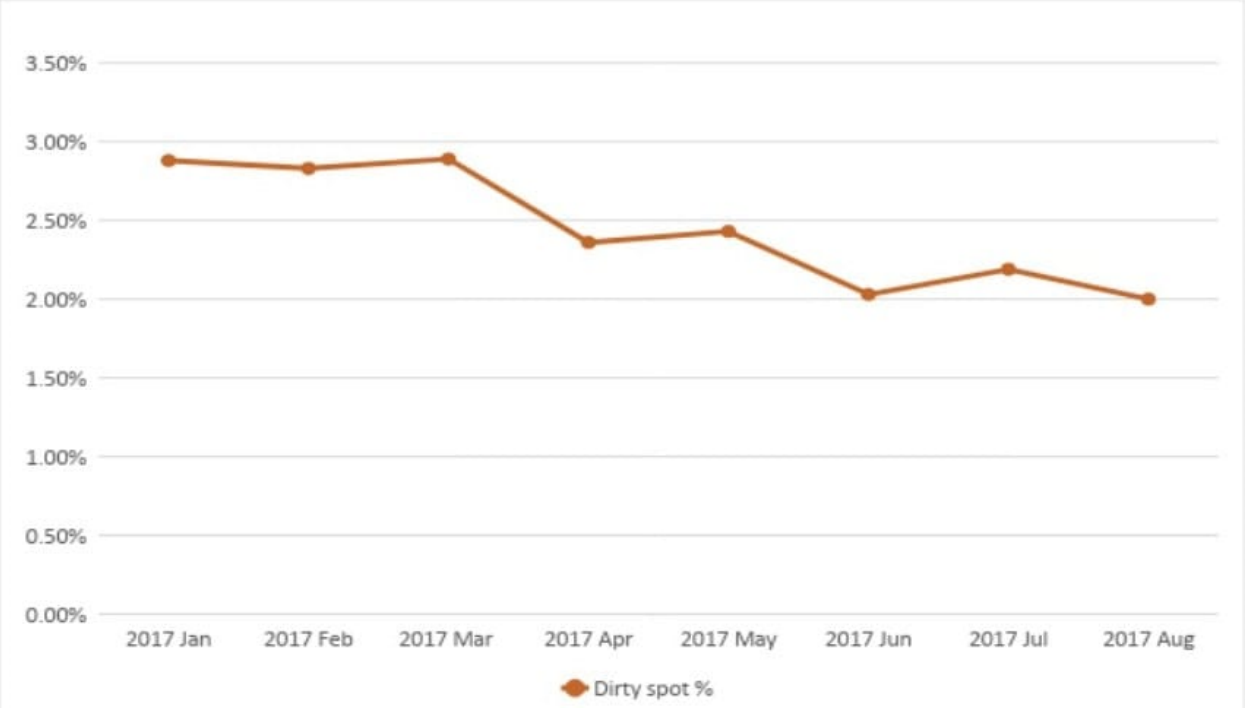

Figure 14: Mother Color Ltd. output dirty spot percentage from January 2017 to August 2017.

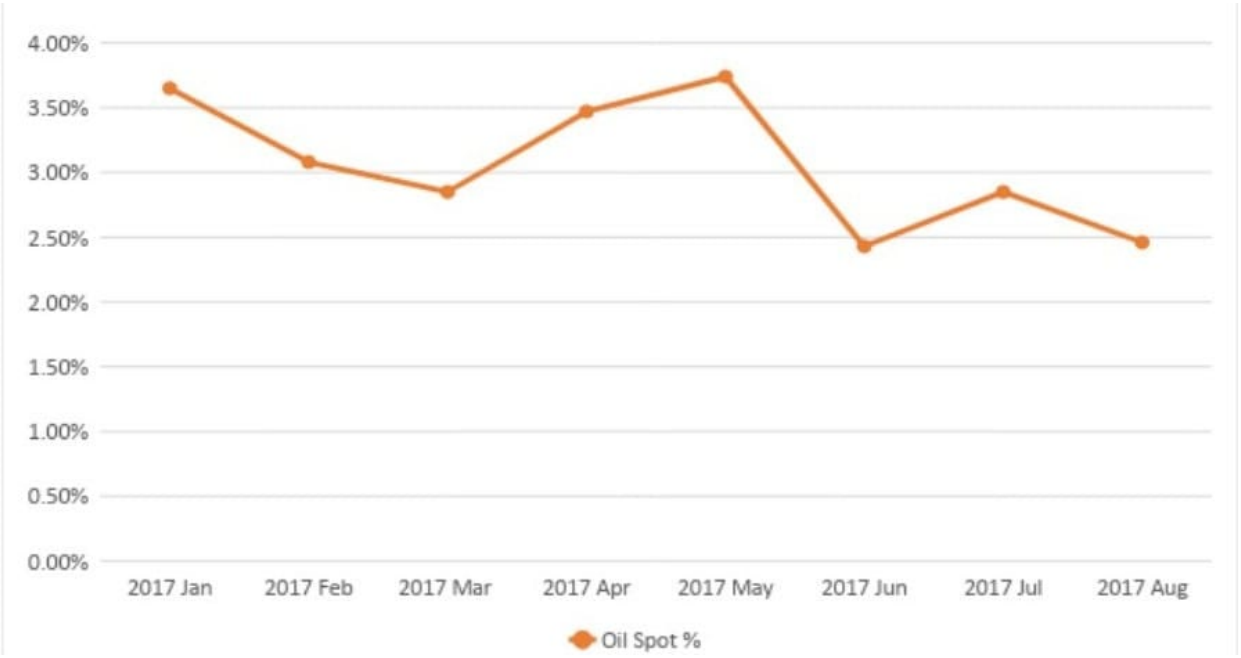

Figure 15: Mother Color Ltd.'s Oil Spot Percentage in Production from January to August 2017

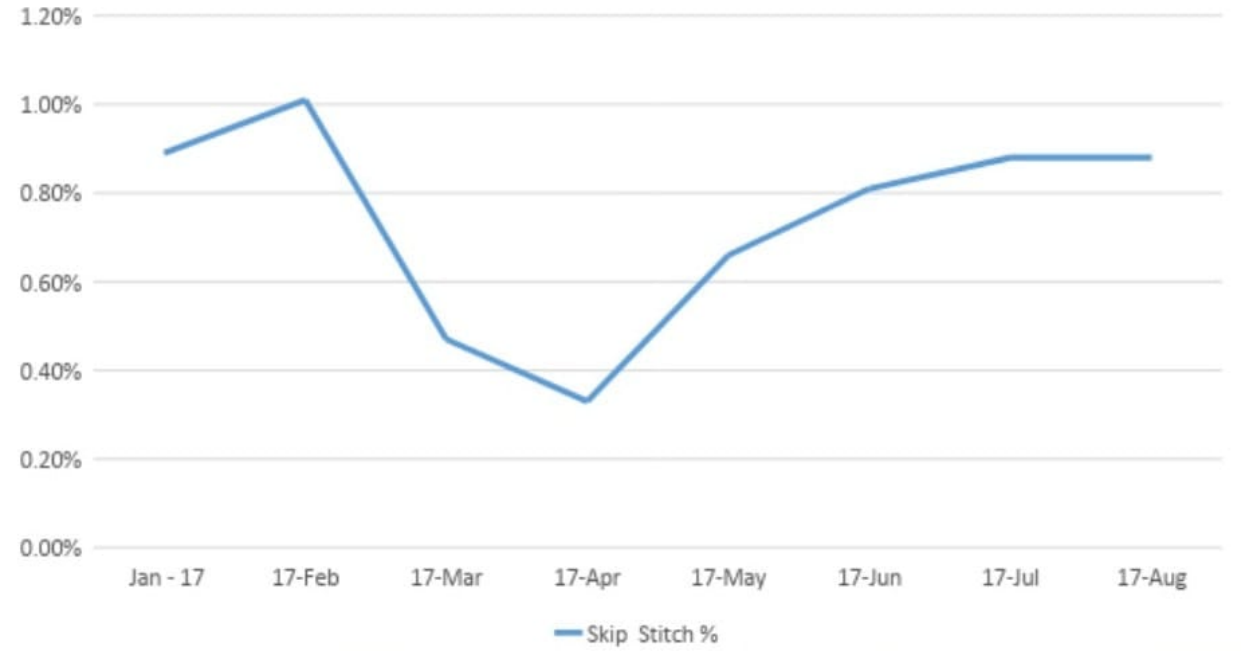

Figure 16: From January 2017 through August 2017, Mother colour Ltd.'s output saw a % of skip stitches.

5.4 Possible Future Suggestions

The textile industry is a complex and highly competitive industry that requires efficient processes to maintain profitability. Implementing lean principles can help textile manufacturers streamline their operations, reduce waste, and improve quality, ultimately leading to increased productivity and profitability. Here are some future recommendations for applying lean principles in the textile industry:

Implement just-in-time (JIT) production: JIT production involves producing goods only when they are needed, rather than keeping large inventories of finished goods. This can help reduce waste, improve efficiency, and decrease lead times, ultimately resulting in cost savings.

Use visual management systems: Visual management systems, such as Kanban boards and Andon lights, can help improve communication and make it easier to identify and address issues in real-time. This can help reduce downtime, increase efficiency, and improve quality.

Focus on continuous improvement: Continuous improvement is a key aspect of lean manufacturing. Encouraging employees to identify and address inefficiencies can help improve processes over time, ultimately leading to increased productivity and profitability.

Optimize equipment and machinery: Equipment and machinery are essential to the textile industry, but they can also be a significant source of waste and inefficiency. Optimizing equipment and machinery can help reduce downtime and improve productivity.

Streamline supply chain management: Supply chain management is critical in the textile industry, and streamlining processes can help reduce lead times, improve quality, and reduce costs. This can be achieved through better communication with suppliers, implementing JIT inventory systems, and utilizing technology to track and monitor shipments.

Overall, implementing lean principles in the textile industry can help reduce waste, improve quality, and increase productivity and profitability. By focusing on continuous improvement and optimizing processes and equipment, textile manufacturers can remain competitive in an

increasingly challenging market.

Future recommendations intend to increase Lean's productivity. Every firm has improvement plans for the future. In addition to current lean techniques, organizations frequently implement additional lean strategies, such as information sharing and training programs for suppliers and wholesalers. Some organizations are currently determining their current practices. People need to be more aware of these concerns. This suggests they implement a comprehensive learning program before implementing other new practices. In Bangladesh, compared to other countries, most reviewed companies are adopting various lean approaches to some extent, but they must strive toward implementing a comprehensive lean manufacturing system. Due to a lack of legitimate knowledge and information, they needed to locate suitable logic. This suggests a thorough understanding of lean production procedures, which necessitates a good training program for administrators, specialists, and providers. The combined knowledge of many groups can aid in the practical application of lean. The next step for these firms is to examine their structure and modify it over time to align it more closely with the lean methodology. For further enhancement, the following actions may be taken by the organizations:

With training in the various lean methodologies, organizations must increase the skill level of the execution group. An operator can be presented for this purpose. This operator may be an external professional or an inside employee who can train employees and improve their motivation to drive these changes. Obtaining administrative accountability and employee contribution through consistent communication is crucial to lean execution. Top management must communicate a strategy and goal to the employees. To build a genuine bond, reduce the number of service providers to a minimum. This should be attainable by thoroughly analyzing the current providers and then recognizing the finest. The textile industries stand to gain significantly from lean deployment if they establish an organization with lean advertisers to design and update lean techniques, guidelines, training, and meetings addressing lean implementation. The fact that the organizations' leaders' understanding of the lean problems can be interpreted as an impediment to lean execution suggests the necessity of developing an action plan for the organizations to increase the level of awareness of the leaders to achieve

further improvements in lean execution. Businesses must encourage suppliers to incorporate lean into the manufacturing process to achieve the desired quality at a lower cost.

5.5 Analysis of the Findings

The findings of the current inquiry will be contrasted with detailed exams to highlight the good association between the results. This relationship can reveal whether Bangladeshi organisations experience the same restrictions, enabling employees, along with outcomes as comparable initiatives in the past. A modest manufacturer of textiles was concerned with how flexible JIT (just-in-time) execution could enhance. That operated as a US-based organization that annually distributed approximately 90,000 items of clothing. The company produces a wide range of products that are updated annually in terms of design, yarn, and color. Due to the standard production philosophy and the perception of excessive inventory, lengthy waiting times, poor communication, and an ordinary style organization encountered a few challenges. The evaluated textile manufacturers in this study also encountered comparable challenges, such as long lead times, lengthy stock holding periods, varying types of waste with significant quantities, and lengthy transit times.

Substantial difficulty and demand from several sources, such as parent organizations issued by purchaser organizations. The organization's primary objective was to halve supply duration and storage size without compromising standards. In several phases, these objectives were brought nearer to fruition. With the continuous incorporation of kaizen, a skilled and collaborative strategy, the company was able to reduce the lead time from approximately ten weeks to one month. It increased employee engagement from 6% to 28%. In comparison to the pre-lean period, these businesses reduced lead time, inventory holding time, production process duration, etc. In general, the companies increased their overall production while decreasing their inventory waiting period by 28%, their time to market by 25%, their procedure duration by 25%, and the time taken for handover by 25%. In this case, it is anticipated that the organization

with the best gain experienced a halving of lead time. In addition to implementing lean manufacturing to address the issues, the company also implemented JIT. This demonstrates that the companies applied a variety of comparable tools in both studies and experienced multiple comparable improvements. Hence, it is obvious that not everything, but rather the facilitating and inhibiting elements, were the same in the majority of cases. In both situations, consciousness and a competent group of employees are essential. The two instances, the impeding factors included acceptability, managerial strategy, organizational customs, customary imperiousness, and cultural obstacles.

Most organizations under correlation are either the textile or readymade garment sectors. Other approaches, such as lean, JIT, etc., were adopted by firms to address similar problems. Common characteristics of these ways of understanding include working together, staff relationships, the importance of management, etc. Textile organizations in BD can learn from this research since they can adopt lean practices used in different nations. It is inconceivable to quantify the critical progress in these businesses, given that the investigations were conducted under diverse authoritative contexts and settings. According investigations, Bangladeshi organization, like other organizations prepared for lean implementation, can achieve more significant improvements. In any situation, the proper condition is required. If the studied Bangladeshi organizations can achieve a more significant performance improvement, then other Bangladeshi textile organizations can do the same under the right conditions.

6 Conclusion

Lean techniques can cut down on inefficiency and waste. Bangladeshi textile organization has been using 'lean manufacturing'; an essential task to reduce Production time, that's particularly important for future growth in order to maintain worldwide competitiveness. Bangladesh's apparel industry is actively working to adopt numerous lean practices and procedures. However, their implementers need more awareness of lean characteristics, methods and tactics. There are several benefits, including enhanced manufacturing performance, from lean principles, which have helped them achieve business growth. A few supportive variables supported lean execution in these textile businesses, while there is one inhibiting issue. The

investigated organizations have fostered an environment conducive to practical lean application. There is ample opportunity for selected Bangladeshi organizations to increase their performance, similar to the textile industries in other nations.

Like the majority of other theses, the paper presents a few limitations. In the present investigation, lean follows were just examined in a few medium-size businesses, that needs more to evaluate the scenario and quantify the Bangladeshi apparel sector. The paper was written based on indirect findings and observations gathered from public resources, as primary data from the industries could only be located if primary data was present.

6.1 Further Research

The study includess a detailed overview on various lean technologies of the apparel industry. Only some Bangladeshi textile companies are investigated in this article. In future research, however, a more significant number of industries will be required to analyze current production processes more extensively, identify improvement opportunities where the lean concept can be adopted, and use lean tools for continuous improvement. As comparative case study analyses, the Comparative case studies section has solely studied India, the United States, and Bangladesh. In a later study, Bangladeshi apparel companies will be contrasted with those in other countries that use lean. This will help researchers come up with ideas for how to improve the way lean is used in Bangladesh. There have been several areas for improvement when applying lean techniques in the Bangladeshi textile industry. For lean to be widely applied in Bangladesh's textile sectors, further research must identify more criteria besides those already identified.

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