Impact of Lean Manufacturing (LM) Techniques on performances of the Textile Companies in Bangladesh

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Abstract

*This article aims to examine the impact of lean manufacturing (LM) techniques on performance of the Textile Companies in Bangladesh. There are 1461 textile companies in Bangladesh, but in this study the target population area has been considered for Chittagong only. There are 152 textile companies in Chittagong area. Responsible authorities of each company, Head of Administration, Accounts Manager and Production Manager has been considered as population for this study. Consequently, with recognizing at least one responsible person, the target population becomes (152*3) 456. From them, 120 respondents have been taken as sample for this study. This study was conducted on the basis of primary data. Data was gathered using questionnaires developed by the researchers. Data was analyzed using Partial Least Square (PLS) 4.0 software to run Structural Equation Model (SEM) to examine the impact of LM techniques on company performance. It is also found that there was a significant positive impact of LM techniques on performance of the textile companies in Bangladesh. It recommends that the textile companies should develop a policy framework to facilitate faster implementation of the best LM practices such as Just -in Time (JIT), Total Preventive Maintenance (TPM), and Value Stream Mapping (VSM), so that the companies will be able to reduce inventory costs and improve product quality and increase customer satisfactions. Though the study suffered limitation of scope because it covered only textile companies and for Chittagong Zone only but is one of the first to have assessed the impact of lean manufacturing (LM) techniques on performance of the Textile Companies in Bangladesh.*

Keywords: Lean Theory, Textile Companies, JIT, Performance

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1. Introduction

As advancements in manufacturing and operational management approaches continue, Lean Manufacturing (LM) has become increasingly significant in industrial development (Shrafat & Ismail, 2019). Numerous companies are analyzing their operational status to facilitate the adoption of a Lean Manufacturing (LM) technique. This process enhances their ability to comprehend, value, and foster LM culture through the systematic management of waste and the reduction of production time and effort (Rahman et al., 2013). LM is a way of thinking that employs a collection of methods to reduce waste and boost business performance (Womack et al., 1990). Developed by Toyota, a Japanese automaker, the idea has since been copied by numerous other large corporations worldwide as a means of competing in the increasingly globalized market to give focus on the elimination of waste, continuous improvement, and the maximization of value to the customer. (Womack & Jones, 1996; Hosseini et al., 2012). LM is a methodology focused on processes that aims to eliminate all non-value-adding activities and waste. It systematically reframes and restructures business processes into a continuous flow, thereby improving resource utilization and enhancing the firm's capacity to address unplanned challenges (Womack et al., 1990).

According to Ferrazzi et al., (2025) Lean Manufacturing (LM) techniques are rooted in optimizing operations to minimize waste across design and production processes, as well their synergy with the green paradigm is evident. However, despite the intuitive connection between Lean methodologies and environmental sustainability, the scholarly exploration of their impact remains largely underdeveloped. Ferrazzi et al., (2025) studied their research to bridge this gap by conducting a comprehensive systematic literature review to dissect the current understanding of Lean manufacturing practices and their influence on environmental sustainability performance. Buhaya & Metwally (2024) examined whether lean manufacturing practices can mediate the connection between digital technologies and sustainability and it was found positive relationship between lean manufacturing practices and companies' performances.

Currently, "Made in Bangladesh" is regarded as a premier brand and is lauded globally. The realization is attributed to the Garments Industry of Bangladesh, which is significantly reliant on the Textile Companies (Hamid & Dhar, 2021). The textile companies manufacture a diverse array of items for handling.

Substantial inventory levels and working capital are necessary to facilitate uninterrupted production. The textile companies, characterized by its labor-intensive processes and complex supply chains, has increasingly sought to enhance efficiency and competitiveness through the adoption of lean manufacturing techniques.

The textile industry in Bangladesh plays a pivotal role in the country's economy, representing one of the largest sectors in terms of employment and export earnings. However, this industry faces numerous challenges, including intense global competition, cost pressure, and inefficiencies in manufacturing processes. Lean Manufacturing (LM) techniques, which aim to minimize waste while maximizing productivity, have emerged as a strategic approach to enhance operational efficiency and sustainability. The implementation of LM practices in the textile sector has been gaining momentum, yet their impact on performance remains an area of ongoing research.

The adoption of Lean Manufacturing techniques, such as just-in-time production, 5S, value stream mapping, and kaizen, has shown promise in improving key performance indicators (KPIs) like product quality, lead time, and cost reduction. While these practices have been successfully employed in many industries globally, the specific context of Bangladesh's textile companies presents unique opportunities and challenges. Cultural factors, infrastructure constraints, and the skill level of the workforce influence the extent of successful LM implementation. Moreover, the complexities associated with supplier relationships, labor conditions, and regulatory frameworks in Bangladesh further complicate the execution of Lean techniques.

This research seeks to investigate the influence of Lean Manufacturing on the performance of textile companies in Bangladesh, focusing on its role in improving manufacturing efficiency, reducing costs, and enhancing competitiveness in both domestic and international markets. Additionally, it will address the challenges encountered by companies in adopting LM practices and propose recommendations to overcome these barriers. The findings will contribute to bridging the gap in understanding the intersection of Lean techniques and industry-specific dynamics in a developing country context, particularly in Bangladesh.

1.2 Textile Companies of Bangladesh

"Made in Bangladesh" is a branding that has elevated Bangladesh to a renowned position in the global economy. The textile company has long been a significant contributor to Bangladesh's economy as this sector facilitates the garments sector to earn revenues and to contribute to the GDP (Hamid & Dhar, 2021). The textile sector in the Bangladeshi economy accounts for over 12% of the overall GDP, while more than 81% of export earnings derive from textiles and allied items. From a socio-economic perspective, this sector provides employment for almost 5 million individuals, with 80% being female, and creates a substantial clientele for banking, insurance, shipping, transport, hospitality, cosmetics, and toiletries, along with associated economic activities. Of the 1461 textile mills, 796 make fabric, 425 manufacture yarn, and 240 engage in dyeing and printing, with a total capitalization over 6 billion US dollars (BTMA, 2023).

1.3 Statement of the Problem

The textile industry in Bangladesh, a cornerstone of the national economy, faces increasing global competition, rising production costs, and pressure to maintain quality while improving delivery times. Despite being the second-largest apparel exporter in the world, many textile companies in Bangladesh continue to struggle with inefficiencies, waste, and inconsistent performance outcomes. Lean manufacturing, a proven management philosophy focused on minimizing waste and maximizing value, has gained global recognition for enhancing operational efficiency and overall organizational performance production (Hamid & Dhar, 2021; Ondiek, 2016; Khan M. S. R. 2020; Jacobs et al. 2009).

However, the adoption and implementation of lean manufacturing practices in the Bangladeshi textile sector remain inconsistent and poorly understood. Many firms lack the technical expertise, cultural readiness, and strategic alignment necessary to successfully implement lean principles. Furthermore, there is limited empirical research examining the relationship between lean manufacturing practices and performance outcomes—such as productivity, quality, lead time, and cost efficiency. But, so far knowledge goes, there is no specific research within the specific context of Bangladesh's textile industry.

This gap in knowledge raises a research question: *To what extent does the implementation of lean manufacturing influence the operational and financial performance of textile companies in Bangladesh?* Without a clear

understanding of this relationship, textile firms may fail to harness the full potential of lean practices, thereby compromising their competitive edge in the global market. Against this backdrop, thus, the purpose of this study is to examine the impact of Lean Manufacturing (LM) techniques on the performances of Textile Companies in Bangladesh.

1.4 Objectives of the Study

The present study broadly intended to investigate lean manufacturing (LM) techniques and examine their impact on performance. This study seeks to examine the impacts of LM techniques on performances of Textile Companies in Bangladesh.

1.5 Design of the present study

The next section discusses the relevant literature on LM. This is followed by hypothesis development and a description of the study's conceptual framework. Sections 3 and 4 present the research methodology and an analysis of the results of the study; the discussion of the results is shown in Section 5. The paper concludes by considering the key findings and implications before highlighting limitations and future research avenues.

2. Literature Review

This literature review explores lean manufacturing techniques and its impact on company performances, i.e., productivity, quality, cost reduction, customer satisfaction and market share specifically within the context of textile companies in Bangladesh.

2.1 Lean Manufacturing (LM) Theory

LM has been widely used in manufacturing sectors since it was created as a tool to help manufacturers improve operational performance (Joosten et al., 2009). Numerous studies claim that lean investments have several advantages, such as reduced expenses, a more efficient staff, quicker lead times, and higher quality (Shah and Ward, 2007; Al Smadi, 2009). Jasti and Kodali (2015) emphasize that before thinking about implementing lean manufacturing, firms should answer the question, "Why lean manufacturing?" To position their company as a good fit for implementing lean thinking, leaders need to lay the groundwork. This idea is essentially a method rather than a simple tool; it is a way of thinking rather than a piece of software. Lean thinking is an attitude and belief that lean

techniques are the best option, not a tool that can be purchased or an easy method to put into practice (Engelund et al.,2009).

According to Abdulmalek and Rajgopal (2007), Lean management is the process of detecting all types of waste within a supply chain's value stream and utilizing suitable technologies to eradicate waste and minimize lead time. Begam et al. (2013) Contend that lean management promotes waste reduction in manufacturing systems, highlighting that lean is a long-term, systematic methodology designed to encourage minor, incremental modifications in industrial processes to improve quality and efficiency. Lean may significantly enhance cost, delivery, and quality; it is defined by Lander and Liker (2007) as a toolset that, when applied technically and formulaically, achieves a predetermined goal. Keitany and Riwo-Abudho (2014) Lean is characterized as a commitment to continuous improvement that can have a wide range of implications for competitiveness and organizational performance. They suggest that lean methodologies may successfully solve organizational challenges and unite reform projects. Shah and Ward (2007) Lean is defined as a multidimensional technique that integrates many managerial techniques like as quality systems, cellular manufacturing, work teams, supplier management, and just-in-time (JIT) into a cohesive framework. LM is viewed as a company technique that aims to meet client expectations by providing high-quality items. According to the literature, Lean Manufacturing (LM) aims to eliminate or minimize waste through fundamental changes to the complete production system.

2.2 Theory of Constraints (TOC)

The Theory of Constraints (TOC), developed by Dr. Eliyahu M. Goldratt in 1980s, points up the identification and determination of the constraint (or primary limiting factor) within a process to increase its overall efficacy. The TOC has revealed considerable utility in lean manufacturing and supply chain management. This theory offers a targeted methodology to ameliorate the outcomes by addressing the restriction or bottleneck. Vaccaro et al. (2019) demonstrated that integrating TOC with lean manufacturing in a multi-stage manufacturing process out-turn in improved throughput and maximized resource allocation. They addressed that conventional lean methodologies might ignore the constraint and incorporating the TOC into lean strategies facilitates the prioritization of the most vital areas for improvement. Narasimhan et al. (2018) inspected the correlation between Theory of Constraints (TOC) and Supply Chain Management (SCM), underscoring that

supply chains frequently face difficulties due to resource scarcity, demand fluctuations, and production bottlenecks. The authors claim that TOC offers a framework for integrating various components of the supply chain by addressing on constraints, thereby enhancing the system's overall performance. Subsequent study by Banerjee and Mukhopadhyay (2016) denoted that technological advancements like Big Data and Artificial Intelligence may introduce innovative methods for on time management of constraints and identification, thereby boosting the efficiency of TOC in lean supply chain.

2.3 Resource-Based View (RBV)

The Resource-Based View (RBV) is a strategic management theory positing that a company's internal resources are vital for bringing-off an everlasting competitive advantage. The RBV addressed that resources such as physical assets, organizational competencies and human capital can improve a company's performance, value, uniqueness, non-substitutability and inimitability. James et al. (2019) talked more about how companies use RBV to make the most of their resources and run lean operations. They said that companies with highly competent workers and strong relational capital (trust and collaboration among employees) are better able to successfully use lean concepts. Chen and Li (2019) discussed how the Resource-Based View (RBV) might facilitate collaboration among suppliers in lean supply chains. The study indicated that enterprises fostering robust, enduring partnerships with their suppliers grounded in trust were more proficient in executing lean methodologies. Organizations can leverage their relational assets to enhance operational efficiency and optimize the responsiveness of their supply chains. Halliday and Bowles (2022) assert that the Resource-Based View's dependence on resources fails to sufficiently elucidate the mechanisms of competition and market dynamics. Organizations possessing superior resources may initially have a competitive advantage; but, this advantage may diminish over time as innovative concepts emerge or as rivals replicate successful strategies.

2.4 LM Practices in the Textile Companies

The categorization of even the most common lean practices by scholars and researchers varies, which is indicative of the authors' varying backgrounds. Consequently, there is no complete accord on these practices. Behrouzi and Wong (2011) indicate that lean practice implementation typically fails owing to a lack of clarity and inadequate techniques to lean management and

performance monitoring. Lean manufacturing involves a number of strategies for optimizing production processes. Key techniques include Just-In-Time (JIT) production, Total Preventive Maintenance (TPS), Value Stream Mapping (VSM), 5S (sort, set in order, shine, standardize, sustain), and Kaizen (continuous improvement). (Ohno, 1988; Liker, 2007). These strategies help to streamline operations, reduce lead times, and improve overall efficiency, making them especially essential in the industrial sector.

These strategies help to streamline operations, reduce lead times, and improve overall efficiency, making them especially essential in the industrial sector. One research project by Kong et al., (2024) examined how lean techniques may be applied to modernize the clothing industry, highlighting the significance of examining the entire production line and procedure to increase output and efficiency in general. Kong et al., (2024) highlighted how to improve the performance of the clothing manufacturing industry by combining lean thinking, JIT, automation development, value stream mapping (VSM), and capacity demand planning.

A framework has been created for the implementation of lean manufacturing in the Indian textile industry. The researchers acknowledged that the complex nature of the textile industry, which is characterized by inflexible automated technology and a large volume of low product diversity, poses significant challenges to the application of lean manufacturing techniques. (Prasad et al., 2020). Another study focused on the awareness and implementation of lean manufacturing in Bangladesh's apparel industry (Bashar & Hasin, 2018). The findings show that while Bangladeshi garment producers are aware of the potential benefits of lean manufacturing, there is variation in the degree of adoption, with some companies actively putting lean tools and processes into place while others are unsure of the long-term advantages. Lean techniques can lower waste, non-value-added processes, production costs, labor time, and lead time in the clothing industry, according to a case study on knit jackets. (Hasan et al., 2019).

Among the mentioned Lean Manufacturing techniques, this study considers three most used techniques for the textile companies, i.e., JIT, TPS and VSM as independent variables to justify the impact of Lean Manufacturing Techniques on Company Performances.

2.4.1 Just-In-Time (JIT) Production

Through careful scheduling of production to precisely match customer demand, Just-In-Time (JIT) production decreases waste and inventory levels. (Monden, 1993). A fundamental component of lean manufacturing is the Just-In-Time technique, which seeks to reduce inventory levels and boost supply chain efficiency overall. (Singh & Ahuja, 2012; Kootanaee et al., 2013; Beard & Butler, 2000). JIT can greatly reduce lead times and holding costs in the textile sector, improving overall responsiveness to market fluctuations (Naylor, Naim, & Berry, 1999). Research has shown that implementing JIT results in lower costs and higher-quality products. (Feld, 2000). Chavez et al. (2019) investigated the application of Just-In-Time (JIT) manufacturing in the automotive sector and discovered that through waste reduction, lead time reduction, and production process optimization, JIT techniques greatly increased efficiency.

Therefore, to determine whether JIT has significant and positive effects on Performance, directly or indirectly, it is hypothesized that:

H1: The practice and implementation of JIT affects performance of the Textile Companies of Bangladesh.

2.4.2 Total Preventive Maintenance (TPM)

A proactive and cost-effective technique to equipment maintenance is the TPM program. All levels of the organization must support this integrated technique. By employing a comprehensive maintenance plan that covers the equipment's whole lifecycle and all related domains, it maximizes equipment efficiency. (Kolanjiappan, 2015; Elagina et al., 2020; Shah & Ward, 2007). Total Productive Maintenance improves company performance in a number of areas, such as customer satisfaction, employee morale, safety and hygiene, and operational efficiency. TPM aims to increase the overall efficacy of the equipment by including every employee in its upkeep. Predictive and preventative maintenance are given priority in order to boost dependability and decrease downtime. (Garre et al., 2017; Rahmanasari et al., 2021; Elagina et al., 2020). Wilson et al. (2000) claimed that the six major losses are lessened when the TPM's main objectives are met. Breakdowns, idling and small stoppages, defects and rework, start-up and yield losses, and set-up and adjustment losses are the six productivity-draining losses.

Therefore, to determine whether TPM has significant and positive effects on Performance, directly or indirectly, it is hypothesized that:

H2: The practice and implementation of TPM affects performance of the Textile Companies of Bangladesh.

2.4.3 Value Stream Mapping

A visual tool called Value Stream Mapping (VSM) is used to assess and plan the information and material flow needed to deliver a product to the consumer. (Rother & Shook, 2003). In the textile companies, VSM can help identify bottlenecks and areas of waste, facilitating targeted improvements that lead to increased productivity and quality. Research by Shah and Ward (2003) shows that businesses using VSM see notable improvements in performance, especially in terms of production efficiency. Practitioners looking to find and remove waste frequently choose value stream mapping because of its adaptability as a lean tool for visualizing and analyzing the flow of resources and information. (Salwin et al., 2021; Henao et al., 2019). A study conducted by Bhamu et al., (2012) has shown how businesses may increase coordination between various production stages, cut cycle times, and streamline their processes with VSM. A more effective production system resulted from managers being able to more easily implement changes and assess the success of lean initiatives thanks to the visualization that VSM offered. Therefore, to determine whether VSM has significant and positive effects on Performance, directly or indirectly, it is hypothesized that:

H3: The practice and implementation of VSM affects performance of the Textile Companies of Bangladesh.

2.5 Lean Manufacturing and Performance

Lean Manufacturing (LM) is known for its focus on eliminating waste, improving quality, increasing productivity, enhancing responsiveness to customer needs and to improve market share.

2.5.1 Impact of LM on Productivity

The adoption of lean manufacturing techniques has a demonstrable positive impact on productivity within textile production. Lean production, a system of production focused on the systematic identification and elimination of waste across the whole value chain, has been widely embraced by enterprises seeking

to improve operational efficiency and profitability (Yadav et al., 2020; Gijo et al., 2018; Gherghea et al., 2020; Cuatrecasas, 2004). The existing literature on lean production emphasizes its capacity to minimize waste, accelerate delivery, cut costs, and raise the quality of products and services, rendering it an appealing technique for firms aiming to improve their competitiveness (Cuatrecasas, 2004; Shah & Ward, 2007). However, as stated by Womack and Jones, the lack of a uniform definition of lean production has occasionally led to obstacles in its application and monitoring (Shah & Ward, 2007).

2.5.2 Impact of LM on Quality

Lean production in the textile sector also has the important advantage of improving quality. Defect prevention and continuous improvement are key components of lean procedures, which can increase the quality of products (Srinivasan & Kothari, 2015; Gijo et al., 2018). Numerous sectors have embraced the fundamentals of lean, such as waste reduction, continuous improvement, and employee respect, in order to promote quality and operational excellence (Balzer et al., 2016).

2.5.3 Impact of LM on Cost Reduction

Lean manufacturing's main goal is cost reduction. Manufacturers of textiles can save a lot of money by cutting waste and streamlining operations. According to existing research, using lean concepts can result in considerable cost savings across a range of industries by optimizing production processes, increasing operational effectiveness, and reducing wasteful spending (Shah & Ward, 2007; Zuting et al., 2014; Jiménez et al., 2019; Garre et al., 2017). In textile production, lean tactics, such as decreasing material waste and boosting worker efficiency, contribute to lower operational costs, allowing for competitive pricing (Womack et al., 1990).

2.5.4 Impact of LM on Customer Satisfaction

One of the key benefits of lean production is its focus on increasing customer value. As noted by (Dhariwal et al., 2017), the key ideas of lean include identifying customers and specifying value which are consistent with the goal of increasing customer happiness. Lean production strategies, such as value stream mapping and just-in-time delivery, have been found to improve customer response and minimize cycle times, resulting in a better customer experience (Garre et al., 2017).

2.5.5 Impact of LM on Market Share

Lean production, a widely used manufacturing technique, has attracted substantial attention in recent years due to its potential to improve operational efficiency and strengthen a firm's competitive position (O. P. Yadav et al., 2017; Pereira & Tortorella, 2018; G. Yadav et al., 2020). The literature currently in publication indicates that a company's market share may benefit from the adoption of lean production. In order to help manufacturing organizations, especially those in developing nations, implement lean manufacturing, scholars have emphasized the creation of frameworks for this technique.

2.6 Operationalization of the Variables:

The above-mentioned hypotheses and variables can be depicted as follows:

Table-1: Operationalization of Variables

Objective	**Variable Type**	**Indicators/Items**	**Expected Effect/ Effects**	**References**
To determine the impacts of **JIT** as a Lean Manufacturing **(LM)** Technique on the performances of textile companies in Bangladesh.	Independent	JIT is as a tool to minimize inventory levels	**Positive**	Kumar and Kumar (2012), Modi and Thakkar (2014), Khanchanapong et al. (2014), Kasemsap (2014), Saurin et al. (2011)
		JIT is as a tool to align production schedules closely with customer demand		
		JIT is as a tool to lessen holding costs		
		JIT is as a tool to decrease lead times		
		JIT is as a tool to improve product quality		
To determine the impacts of **TPM** as a Lean Manufacturing	Independent	TPM is as a tool to minimize breakdowns	**Positive**	Shah and Ward (2003), Wickramasinghe and Perera (2016),
		TPM is as a tool to minimize set-up		

(LM) Technique on the performances of textile companies in Bangladesh.		and adjustment losses		Wilson et al. (2000)
		TPM is as a tool to minimize idling and minor stoppages		
		TPM is as a tool to minimize defects and rework		
		TPM is as a tool to minimize reduced speed		
		TPM is as a tool to minimize start-up and yield losses		
To determine the impacts of **VSM** as a Lean Manufacturing **(LM)** Technique on the performances of textile companies in Bangladesh.	Independent	VSM is as a tool to identify bottlenecks	**Positive**	Engelund et al. (2009), Wan and Chen (2008), Bateman et al., (2014).
		VSM is as a tool to identify areas of waste		
		VSM is as a tool to facilitate targeted improvements		
Company Performance	Dependent	Productivity		Hashmi et al. (2015), Rasi et al. (2015), Agus and Iteng (2013), (Belekoukias et al., 2014), Godinho Filho et al. (2016), Panwar et al., (2018)
		Quality		
		Cost Reduction		
		Customer Satisfaction		
		Market share		

Source: Authors own works

2.7 Conceptual Framework

A **conceptual framework** is a **structured, visual or narrative representation** of how key variables or concepts in a research study are expected to relate to each other.

From the above-mentioned theories and variables, the study considers the following conceptual framework.

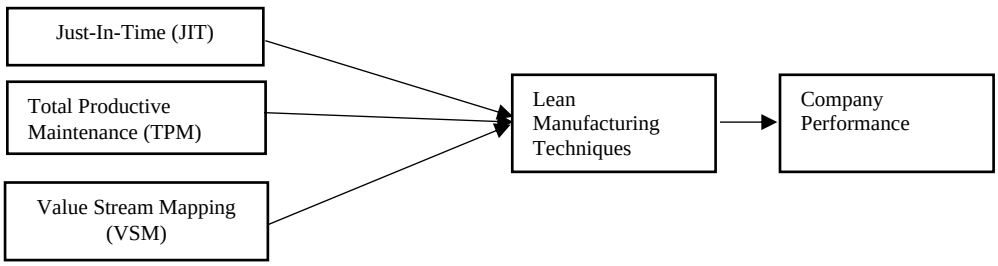

Figure 1: Conceptual Framework

3. Methodology of the Study

3.1 Area of the Study

This study utilizes primary data, with Chittagong designated as the study location for the convenience of data collecting. Consequently, the target population for this study is confined to Chittagong.

3.2 Target Population

Table 2 indicates that Bangladesh has 1,461 textile enterprises; however, this study focuses exclusively on the Chittagong region which contains 152 textile companies.

Table-2: Number of Textile Firms in Bangladesh and Chittagong

Categories of Textile Firms	Number of Firms in Bangladesh	Number of Firms in Chittagong (Studied Population)
Yarn Manufacturing Mills	425	52
Fabric Manufacturing Mills	796	79
Dyeing-Printing-Finishing Mills	240	21
Total	1461	152

Source: BTMA

3.3 Sampling Techniques and Sample Size

3.3.1 Sampling Techniques

The researcher employed simple random sampling to choose respondents from each stratum to represent the perspectives of the remainder within that stratum. Simple random sampling provided each member within each category an equal and independent probability of selection, thus minimizing bias (Mugenda & Mugenda, 2003). Purposive sampling was employed to choose important informants, including administrators, storekeepers/accountants, and operations/production department personnel, due to their expertise in lean manufacturing and performance. This method was used to guarantee that the essential elements and feedback of the study were accurately captured, hence enhancing the probability that the variability inherent in any social phenomenon was reflected in the data (Barreiro & Albandoz, 2001; Schwandt, 2001).

3.3.2 Sample size

Table-2 indicates that the total number of textile enterprises in Chittagong is 152. This study utilized a survey encompassing all 152 existing organizations. The research population comprises the relevant authorities within each organization, specifically the Head of Administration, Store Keeper/Accounts Manager, and Production Manager. Consequently, accounting for at least one interested individual, the target population totals 456 (152*3). From the 456 populations, 120 respondents have been selected as the sample for this study. The computation indicates that a sample size of 82 is deemed appropriate for this investigation.

Table-3: Number of Population and Sample

Categories of Work Positions	Studied Population in Number	Studied Sample in Number	Proportion of population	% of Sample
Head of Administration	152	20	13.16	16.67%
Accounts Manager	152	60	39.47	50%
Operations/ Production Manager	152	40	26.32	33.33%
Total	456	120	26.31	100%

Source: Authors' field survey and own calculation

From the above table, it is seen that majority (50%) of the respondents are from accounts. It is considered more convenient to get access with them and they are related with store keeping and inventory handling issues. Head of administration was considered as respondents to know their thinking on lean manufacturing techniques.

3.4 Data Collection Methods

The researchers worked on quantitative data collection method. Questionnaires were constructed based on the research objectives. Self-administered questionnaires were completed by those who can interpret the questionnaire.

3.5 Data Analysis and Presentation

Data preparation was performed on the completed questionnaires by revising, coding, entering, and cleaning the data. This was done prior to the processing of the acquired data when it was being processed. Having this information would be helpful in ensuring that the responses are accurate and complete. Data was analyzed using descriptive statistics and the theoretical relations, i.e., impact of Lean Manufacturing (LM) techniques (independent variable) on performance (dependent variable) were tested by structural equation modeling with the help of PLS 4.

4. Data Analysis and Findings

In this section an attempt has been made to display the general information that are collected from the field. And then, in the next, it is sought to explore the Lean Manufacturing (LM) techniques used by textile companies in Bangladesh. And finally, it is tried to examine the impact of Lean Manufacturing (LM) techniques on performances of textile companies in Bangladesh.

4.1 Descriptive Analysis

In this section, an overview of demographic characteristics of the respondents has been displayed to justify the sample which represents the population.

Table-4: Descriptive Statistics of Demographic Characteristics (N=120)

Characteristic		Frequency	Percentage
Department (Respondents)	Head of Administration	20	16.67
	Accounts Manager	60	50.00
	Production Manager	40	33.33
	Total	120	100.00
Age grade of the respondents	30-40	13	10.8
	40-50	86	71.7
	50-60	20	16.7
	60 and above	1	.8
	Total	120	100.0
Educational level	Bachelor	30	0.25
	Master	74	61.7
	Professionals	16	13.33
	Total	120	100.0
Service Length of the Respondents	Below 10	25	20.8
	10-20	72	60.0
	20-30	23	19.2
	Total	120	100.0

Source: Primary Data

The table of respondents indicates that 20 (16.67%) were from administration, responsible for guiding operating techniques; 60 (50%) were from accounting, tasked with verifying and processing payments; and 40 (33.33%) were from manufacturing. The percentages indicate that respondents possessed sufficient experience to complete the questionnaire, rendering their information precise and valuable for analyzing Lean Manufacturing and its effect on organizational performance.

Based on the ages of the people who answered, 86 (71.7%) were between 40 and 50 years old, while the rest were between 30 and over 60 years old. These

percentages show that the people who answered the questionnaire were mature enough to understand and answer the questions.

The table above indicates that the respondents possessed sufficient education to complete the questionnaire. Seventy-four individuals (61.7%) possessed a master's degree or an equivalent qualification, 13.33% held a professional degree, while the remainder obtained a bachelor's degree, so indicating the reliability of our data.

The chart above indicates that the majority of respondents, constituting 60% of all replies, had been employed by the company for a duration of 10 to 20 years. 20.8% possessed less than 10 years of experience, while 19.2% had 20 to 30 years of experience. This indicates that the respondents had been employed by the organization for an extended duration.

4.2 Measurement Model

The measuring model evaluates reliability and validity. Three instruments are typically utilized to evaluate the reliability of a research model: construct reliability (Cronbach's alpha), composite reliability (CR), and loadings. Construct reliability is deemed acceptable when alpha is at least 0.60 and composite reliability is 0.70 or higher (Hair et al., 2017). The employed constructions meet the reliability criterion when their loadings are 0.60 or greater (Bagozzi and Yi,1988). The confirmatory factor analysis results demonstrated high internal consistency levels within the dimensions, surpassing 0.60. All composite reliability (CR) and loading values surpassed the acceptable thresholds of 0.70 and 0.60, respectively.

Validity is classified into two categories: discriminant validity and convergent validity. The comprehensive evaluations of discriminant validity are (Hair et al., 2017; Urbach and Ahlemann, 2010; Fornell and Larcker, 1981):

- Cross-loadings: the construct loadings should be higher than the cross-loadings values in its row and column (Table 10).
- HTMT should be <0.90 (Table 9).
- Each construct's correlation values should be less than √AVE (Table 9).

Since all criteria for discriminant validity have been satisfied, it can be concluded that all constructs in the study exhibit discriminant validity. Convergent validity refers to the evaluation of whether constructs effectively measure their intended variables (Hattami et al., 2022). The average-variance-extracted (AVE) value serves as a measure for evaluating convergent validity; it is essential that the AVE for each construct is set at 0.50 or above. (Fornell and Larcker, 1981). As seen in Table 8, this criterion was satisfied, suggesting that the constructs possessed convergent validity.

Prior to doing structural model analysis, the researcher must first assess the issue of multicollinearity, which is considered unexpected in any study (Hair et al., 2017). Examining the correlation matrix of variables is the most straightforward method to identify multicollinearity issues. The variance inflation factor (VIF) is the predominant method employed in regression analysis to assess multicollinearity concerns (Hattami et al., 2022). Generally, all VIF values should be less than 3.3 or, at most, 5 (Kock, 2017; Hair et al., 2017). Table 8 indicates that Value Stream Mapping (VSM) possesses the highest VIF value (3.607), suggesting that there is no multicollinearity problem in this study.

Table-5: Measurement Model

Constructs	Construct Reliability; Cronbach's alpha(α)	Composite Reliability (CR)	Average-Variance-Extracted (AVE)	Just-in Time (JIT)	Total Preventive Maintenance (TPM)	Value Stream Mapping (VSM)	Performance (Perf.)	Variance Inflation Factor (VIF)
Just-in Time (JIT)	0.918	0.925	0.753	0.868				2.061
Total Preventive Maintenance (TPM)	0.933	0.933	0.882	0.394	0.939			2.049
Value Stream Mapping (VSM)	0.960	0.987	0.925	0.209	0.213	0.962		3.607
Performance (Perf.)	0.957	0.974	0.886	0.428	0.366	0.289	0.942	

Source: Authors own works

Table-6: Heterotrait-Monotrait Ratio (HTMT)

	JIT	**TPM**	**VSM**	**PER**
JIT	1			
TPM	0.423	1		
VSM	0.225	0.225	1	
PER	0.441	0.379	0.293	1

Source: Authors own works

Table 7: Cross Loadings

		JIT	TPM	VSM	PER
JIT	JIT 1	***0.814***	0.237	0.189	0.362
	JIT 2	***0.830***	0.317	0.133	0.411
	JIT 3	***0.892***	0.422	0.206	0.424
	JIT 4	***0.881***	0.327	0.268	0.314
	JIT 5	***0.918***	0.398	0.113	0.311
TPM/TPS	TPM 1	0.433	***0.966***	0.153	0.347
	TPM 2	0.307	***0.928***	0.235	0.338
	TPM 3	0.369	***0.924***	0.214	0.346
	TPM 4		Not loaded		
	TPM 5		Not loaded		
	TPM 6		Not loaded		
VSM	VSM 1	0.188	0.215	***0.975***	0.270
	VSM 2	0.223	0.191	***0.949***	0.227
	VSM 3	0.198	0.207	***0.961***	0.321
Performance (Perf.)	PER 1	0.475	0.418	0.278	***0.944***
	PER 2	0.321	0.253	0.232	***0.886***
	PER 3	0.392	0.321	0.267	***0.979***
	PER 4	0.400	0.357	0.303	***0.955***
	PER 5				Not loaded

Source: Authors own works

4.3 Structural Equation Modeling and its Analysis

Structural Equation Modeling (SEM) is the most suitable and highly recommended tool for analyzing hypotheses in social and behavioral sciences (Benitez et al., 2020). A two-stage strategy was used, in accordance with Hair et al. (2010). First, scales used in earlier research were used to construct a structural model. After the structural model was examined to look at a number of theories, the next stage was to test it. Prior to attempting to make inferences about the relationships postulated in the study model, this procedure ensured that the constructs and measures were legitimate and trustworthy (Barclay et al., 1994).

The structural model involves the verification of several indices to determine the acceptance or rejection of the hypothesis. It is proposed to utilize the coefficient of determination (R^2) to evaluate the predictive accuracy of the model, path coefficients (β) to measure the strength of latent constructs, and p-values or t-values to ascertain the acceptance of hypotheses (Fornell and Cha,1994). The indicated factors suggest a connection between the underlying constructs, as the R^2 reflects the model's ability to predict accurately (Falk and Miller, 1992). The R^2 value ranges from 0 to 1; a higher value indicates a more accurate prediction. In conclusion, the R^2 value is considered substantial and sufficient when it exceeds 0.10 (Al-Hattami et al., 2022). In this study, roughly 26.0% (Figure-1) of the variance in “Company Performance” was explained by JIT, TPS and VSM.

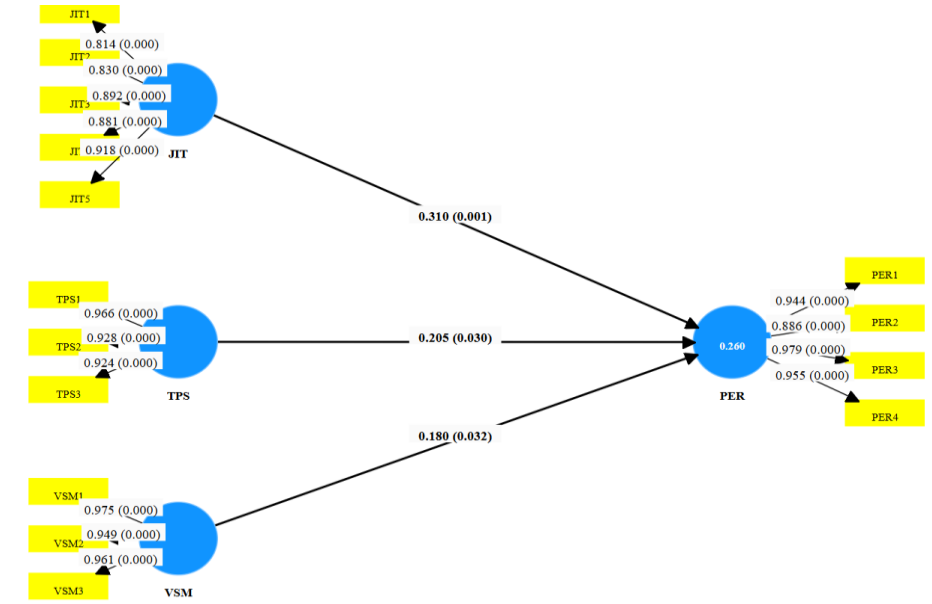

Figure-2: Confirmatory factor analysis model done by PLS 4

Table 8: Structural Model

Path	β	t	p	Remarks
H1: JIT → Per	0.310	3.442	0.001	Supported
H2: TPM → Per	0.205	2.165	0.030	Supported
H3: VSM → Per	0.180	2.141	0.032	Supported

Source: Research Data

5. Hypotheses Measurement and Discussion

H1: JIT → Per

As expected, the JIT as an important dimension or tool of lean manufacturing techniques has a significant positive effect on performance (β = 0.310, p < 0.001; table-11); thus, supporting hypotheses H1. These findings are in line with Engelund et al., 2009; Fullerton and Wempe, 2009; Dora et al., 2014).

The results imply that JIT enhances company performances. JIT minimizes the need for large inventories, which reduces storage costs, insurance costs, and the risk of inventory obsolescence. The company only orders materials when needed, helping to reduce carrying costs significantly. JIT minimizes production and delivery times by aligning production schedules with demand. This can significantly reduce lead times, enhancing a company's ability to respond to market changes and customer demands more quickly. With JIT, there's a stronger emphasis on quality at every stage of production. These findings are in line with Kumar and Kumar (2012); Modi and Thakkar (2014) and Khanchanapong et al. (2014). Since materials are delivered in smaller quantities, there's less room for defective parts to be used, and the company can focus on producing high-quality products more consistently. JIT allows companies to better align production with customer demand, which helps to avoid the issues of stockouts or overproduction. This responsiveness can enhance customer satisfaction by delivering products in the right quantity and at the right time. So, it can be said that when implemented successfully, JIT improves cost efficiency, operational effectiveness, product quality, and customer satisfaction, contributing to enhanced overall performance and profitability (Kasemsap 2014, Saurin et al., 2011.) But it requires a high level of coordination and reliable suppliers. Poor implementation or external disruptions can negatively impact operations and performance. Thus, it can be said to improve Lean Manufacturing implementation and its application among Bangladeshi Textile companies, these dimensions should be evaluated closely.

H2: TPM → Per

As stated in the literature review, one of the primary goals of TPM is to reduce machine downtime by preventing breakdowns. The reduction in unplanned downtime leads to more consistent production, fewer disruptions, and better use of manufacturing resources. As expected, the TPM as an important dimension or tool of lean manufacturing techniques has a significant positive impact on performance ($\beta = 0.205$, $p < 0.030$; table-11); thus supporting hypotheses H2. These findings are in line with Keitany and Riwo-Abudho, 2014; Hashmi et al., 2015.

TPM ensures that equipment is regularly checked and maintained, resulting in higher availability and uptime, which in turn increases production capacity and output. While TPM requires initial investment in training, tools, and systems, it can lead to long-term savings. Preventive maintenance reduces the need for expensive

emergency repairs, part replacements, and extensive downtime. Well-maintained equipment typically operates more efficiently, which can reduce energy consumption, thereby lowering operational costs. Preventing equipment failures reduces the chances of producing defective products. TPM helps ensure that machinery operates within the specified parameters, reducing variability and improving product quality. These findings are in line with Wickramasinghe and Perera (2016). TPM reduces the risk of production losses due to equipment failures, leading to more efficient use of materials and resources. This results in less waste and contributes to a more sustainable manufacturing process (Hashmi et al. (2015), Rasi et al. (2015), Agus and Iteng (2013).

Thus, it can be said that **Total Preventive Maintenance (TPM)** affects **company performance** positively, especially when TPM is implemented comprehensively across the organization. TPM helps reduce downtime, increase equipment reliability, improve product quality, and cut maintenance costs—all of which contribute directly to enhanced company performance. By aligning equipment maintenance with production goals and involving employees in the process, TPM fosters a culture of continuous improvement, ultimately enhancing operational efficiency and providing a competitive advantage. So, to improve Lean Manufacturing implementation and its application among Bangladeshi Textile companies, these dimensions should be evaluated closely

H3: VSM → Per

As predicted, the VSM as an important dimension or tool of lean manufacturing techniques has a significant positive impact on performance ($\beta = 0.180$, $p < 0.032$; table-11); thus, supporting hypotheses H3. These findings are in line with Pozo and Da Silva (2013); Forrester et al. (2010).

VSM helps organizations visualize their entire value stream and identify various types of waste, such as overproduction, waiting times, excess inventory, unnecessary transportation, and defects. By eliminating or minimizing waste, companies can streamline their processes and achieve greater operational efficiency. With the information from a value stream map, companies can identify areas where the production flow is disrupted or delayed. Streamlining these processes can reduce cycle time and improve throughput, leading to faster production and lower operational costs. By improving the flow and reducing

inefficiencies, VSM helps identify quality issues early on, which reduces defects and the need for costly rework. This can lead to substantial savings in production costs and improved profitability. By mapping out the entire value stream, companies gain insights into where errors or defects are most likely to occur, allowing them to implement targeted improvements. Better process control leads to more consistent product quality. By improving production flow, reducing lead times, and ensuring that production processes are more predictable, VSM can lead to more reliable and timely deliveries which directly enhances customer satisfaction (Engelund et al. (2009), Wan and Chen (2008), Bateman et al., (2014).

The **impact of Value Stream Mapping (VSM)** on **company performance** is significant and positive. VSM helps organizations improve operational efficiency, reduce costs, enhance product quality, shorten lead times, and respond more effectively to customer needs. By providing a clear visual representation of the entire value stream, companies can identify areas for improvement and make data-driven decisions to optimize processes (Belekoukias et al., 2014), Godinho Filho et al. (2016), Panwar et al., (2018). In turn, this leads to increased profitability, competitive advantage, and better alignment with customer demands. So, to improve Lean Manufacturing implementation and its application among Bangladeshi Textile companies, these dimensions should be evaluated closely.

6. Conclusion, Limitations, Contributions and Areas for Future Research

6.1 Conclusion

The implementation of lean manufacturing techniques has emerged as a critical driver of operational excellence and competitive advantage in Bangladesh's textile industry. As global market dynamics demand greater efficiency, agility, and customer responsiveness, textile firms in Bangladesh are increasingly recognizing the value of lean practices such as Just-in-Time (JIT), TPM and Value Stream Mapping. The findings suggest that when effectively implemented, these techniques lead to significant improvements in key performance indicators, including cost reduction, quality enhancement, lead time minimization, and overall productivity. For the Bangladeshi textile sector to maintain its global competitiveness, particularly in the face of rising production costs and environmental pressures, widespread and strategic

adoption of lean manufacturing is imperative. Future efforts should focus on building lean capabilities as core organizational competencies, supported by policy incentives, industry collaboration, and investment in capacity development. Ultimately, lean manufacturing holds significant promise in transforming Bangladesh's textile companies from volume-driven producers to value-driven, performance-oriented enterprises.

This study aims to enhance this area of research by presenting a theoretical framework to analyze the direct and indirect linkages between LM practices and performance.

The primary objectives were to examine the degree of adoption of LM practices and to ascertain any notable disparities in the effects of their implementation on performances of the Textile Companies in Bangladesh. It was found that LM practices had a significant positive influence on performances of the Textile Companies in Bangladesh. This paper advances the idea of Lean Manufacturing by proposing a theoretical framework to assess the degree of implementation of Lean Manufacturing technique by manufacturing entities, particularly for Textile Companies. It provides a theoretical contribution by offering scholars an innovative technique to the lack of empirical investigations conducted in developing nations. It enables manufacturers worldwide to attain substantial competitive advantage in developing nations.

6.2 Limitations of the Study

In case of conducting this study, firstly, the study suffered limitation of scope because it covered only textile companies and for Chittagong Zone only. The study would give a better picture for decision making and for policy reasons if it studied from samples of all textile companies. Secondly, it was not easy to collect data because some of the respondents were of the view that the data sought were sensitive and would amount to giving business secrets. The researchers had to assure them of the confidentiality of the data collected by showing them the introduction letter and affirmation that the information would be kept as confidential as possible. Due to fund constraints, it was challenging for the data collectors to travel several times in whole areas of Chittagong. Time was also a constraint for conducting this study.

6.3 Contributions of the Study

Textile companies of Bangladesh will be able to improve their performances if they could utilize all the LM techniques that have been analyzed in this study. Again, the Textile companies of Bangladesh will be able to know exactly what affects their performances and the solutions they need to apply. If managements have taken consideration LM into practice, the product quality will be improved and high levels of customer satisfaction will be achieved and ultimately profitability will be ensured.

6.4 Areas for Future Research

The present study has been conducted on impact of LM techniques on industrial performance of textile companies in Bangladesh particularly in Chittagong. The study used primary data that was gathered exclusively using a questionnaire. Future studies ought to be conducted to cover other sectors like technology, insurance and banking. Future studies should also be conducted using both primary and secondary data. Further, a study should be conducted focusing on factors affecting the choice of LM techniques. Further research has been recommended on more lead time practices that affect organizational performance other than the present study identified.

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