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Optimizing Operational Performance through Lean Strategies

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***Abstract* – This study examines the effect of lean practices on productivity, waste reduction, product quality, and organizational efficiency in the manufacturing sector of Maharashtra in India. The research is based on data gathered from 43 manufacturing companies, through a structured questionnaire used to question employees and managers with over 5 years of manufacturing experience and awareness of lean principles. The study involves multiple regression analysis using SPSS to analyse the data collected through survey. The outcome of the study has elaborated that employee attitude and introduced methods are vital to the company performance and attainment of the objectives. The results suggest, especially the fact that lean practices can contribute significantly to improvement of productivity and customer satisfaction based on the quality of products and services. The study suggests that employee involvement and empowerment are essential to the success of lean implementation being the main success factors for it. It emphasizes the necessity for employee training, empowerment, and strategic syncing in successful lean implementation. Through laying these factors, manufacturers increase their operational performance and reach sustainable competitive advantages. This research paper provides real value for the practitioners and researchers targeting to improve their lean practices and, in the meantime, promote efficiency in organizations operating in the manufacturing sector, eventually advancing knowledge in lean management.**

***Keywords* – Lean practices, Productivity, Waste reduction, Employee involvement, Customer satisfaction, Lean implementation, Organizational efficiency**

I. Introduction

Lean Thinking

Lean thinking is a way of managing that aims to cut down on things not needed, make work better and increase value in every part of an organization. It started at the Toyota Motor Company in Japan, brought up by Taiichi Ohno and Shigeo Shingo. In 1988, a person named John Krafcik created the idea of "lean thinking". He was studying at MIT. James Womack and Daniel Jones made the idea stronger in their important book called "Lean Thinking". It was first published in 1996. They also added a second edition to it, which came out in 2003 (Womack & Jones, 2003).

Principles of Lean Thinking

According to Womack & Jones (2003), lean thinking has five principles:

- **Specify value:** Determine the needs and wants of the client during this process.
- **Identify the value stream:** Remove those actions and tasks in a process which do not contribute.
- **Guarantee the flow:** Ensure that the processes through which things become valuable are performed well and continue, without stopping or waiting.
- **Pull the value:** Construct and deliver what the customer demands when he needs it directly at his place.
- **Seek perfection:** Watch the process carefully to eliminate waste and improve value more effectively.

Lean Manufacturing Definition

Lean manufacturing is defined as "A philosophy, based on the Toyota Production System, and other Japanese management practices that strives to shorten the timeline between the customer order and the shipment of the final product, by consistent elimination of waste". All types of companies that do manufacturing, process, distribute, or developed software or gave financial services could drastically benefit from the application of the lean management philosophy. Such company can define a certain amount of the value stream, it orders the product to the moment when the customer receives it. Then, lean principles can be applied with the purpose of removing the waste. (Singh, 1999). Also, lean manufacturing is: "Adding value by eliminating waste, being responsive to change, focusing on quality, and enhancing the effectiveness of work force". (Liker, 2004). Another definition for lean manufacturing: "it is a systematic approach to identify and eliminate waste (non- value-added activities) through continuous improvement by following the product at the pull of the customer in pursuit of perfection". (Czarnecki and Loyd, 1998). Also, lean manufacturing is: "A manufacturing philosophy that shortens the time between customer order and the product build/shipment by eliminating sources of waste". (liker and Lamb, 2000).

Lean Production System

Liker J. (2007) examined the performance improvements of lean systems are phenomenal which elevate quality, cost, and delivery time without much sweat. He also referred to a fundamental misconception regarding TPS; instead viewing it as just technical implementation monadically used for receiving predefined results. The lean production approach stated by Shah, R (2007) is a conglomerate of managerial methods like just in time, quality system management, work team group manufacturing and supplier management under a single system. In Petersen, J. (2011), the author who conducted the lean literature review concluded that in most of the writings there is a view that lean is not only a set of tools but also a philosophical approach to lean. Accordingly, lean production can be perceived as the philosophy of perpetual improvement and the respect for people.

Lean Manufacturing Tools

Kanban

Kanban is a tool for putting into practice getting customer pull production and it helps to make sure goods keep moving without waste. It also makes sure we have enough stock, so the material keeps coming in never stopping. People have pointed out that when a company doesn't watch how much material they are giving to the place where products are made, and changes what is being produced there with less notice - it can severely impact this pull system (Mayr et al., 2018; Sanders et al., 2016).

1.4.2 JIT (Just in Time)

JIT is one of the key parts of TPS. It tries to make only what's needed when it's needed at a certain time, day, and amount. Instead of normal methods, it moves manufacturing through the supply chain. It only works with materials if needed by their next step in production. From a point of view, JIT helps to fix problems with making too many goods and move them around by speeding up the time it takes for these products to reach other places. This is good because there are less mistakes made when creating things (Mayr et al., 2018; Sanders et al., 2016).

1.4.3 VSM (Value Stream Mapping)

The value stream includes all tasks needed on the production line right now, including those that add worth and others. The picture shows this flow process. It helps understand how different things affect every level in making something. This check helps us to get rid of waste, make work tasks quick and easy. It also lowers the time it takes and costs while boosting how good we are at our jobs (Wagner et al., 2017).

1.4.4 Kaizen

Kaizen includes all workers in a company. It wants to help them improve constantly, by training and planning how they work better together as teams. This helps find weaknesses and create new ways solve potential problems (Maarof and Mahmud, 2016).

1.4.5 Total Productive Maintenance

Zero mistakes allowed and improving production are two basic needs in the industries where things are made. In this view, we think fixing machines and tools is very important to make sure they work right. This also helps the whole line where things are made. These tasks are very important in smart factories. This is especially true when there's a lot of tech complexity and many smart things to deal with. In this case, if something is put into use without planning it first can cost the company a lot of money. Even when we do timely care and checkup for machines, they can still break down. If an issue pops up on the production lin while it's running, figuring out what caused it may take a lot of time (Mayr et al., 2018; Sanders et al., 2016).

1.4.6 Poka-Yoke

The Poka-Yoke tools help in finding and stopping bad things happening during product making processes. They stop creating items that are not of good quality. This tool makes lists of things needed for creating products on the production lines. It also watches these steps as they are happening, stopping them if there's a problem or mistake found (Zhang, 2014).

Workplace Organization-The Five S's

One of the most powerful methods of continuous improvement is called the 5S, which is the fundamental for a lean company. 5S is the first, modular solution for starting serious waste reduction. S stands for Sorting, Setting, Shining, Standardization, and Sustainment. 5S is a set of rules for workplace setup which is designed to make each worker as well as their work areas more efficient. 5 S are: (Scott, 2011)

Figure 1.1 : 5S (pacific-research.com)

Benefits of Implementing Lean Principles

Enhanced Efficiency: The goal of lean principles is to simplify operations and get rid of waste. Organisations may run more effectively, using less time and resources to supply goods or services, by identifying and removing non-value-added operations Mouzani (2019).

Cost Reduction: By identifying and removing needless expenses linked to overproduction, excess inventory, defects, and waiting periods, lean procedures aid in cost reduction. The organisation saves a lot of money as a result.

Improved Quality: Lean emphasises ongoing development and a decrease in errors. Organisations may raise customer satisfaction by improving the overall quality of their goods and services through process standardisation and the application of quality control techniques (Serrano et al., 2010).

Employee Engagement: A key component of Lean is including workers in the process of continuous improvement. Employee involvement and creativity are encouraged when they are given the tools to solve problems and enhance processes (Robinson & Schroeder, 2015).

Optimized Inventory Management: Just-in-time manufacturing is promoted by lean concepts, which reduces the requirement for surplus inventory. This keeps the supply chain more responsive and lowers holding costs at the same time (Koumanakos, 2008).

Shorter Lead Times: The overall purpose of lean principles is to reduce the lead times through better workflow and by eliminating delays This allows businesses to respond more quickly to their customer needs and market trends (Prajapati & Deshpande, 2015).

Increased Flexibility and Responsiveness: Lean organizations are much more responsive to the changes in customer preferences or any developments of market conditions. Lean practices offer an adaptability that allows for the rapid changes to production timetables and product mixes (Kilpatrick, 2003).

Customer Satisfaction: Lean organizations can increase the customer satisfaction by ensuring the quality, reducing delivery periods, and understanding well the needs of their customers. Happy customers make the loyalist and brand recommender (Goshime et al, 2019).

Enhanced Communication and Collaboration: Lean principles encourage open communication and collaboration among the team members. The implementation of cross-functional teams working in collaboration also enhances the problem solving as well as innovation (Jimmerson et al., 2005).

Strategic Alignment: Many Lean principles require many strategic organizational goals and day- to-day practice to be closely aligned. This strategic alignment guarantees that every action effectively contributes towards the overall goals of an organization (El-Khalil, 2022).

Sustainable Practices: Lean principles promote minimizing the waste in the environment and thus supporting sustainability. This may be accomplished by the proper use of resources and reduction in wastes (Rother & Shook, 1999).

Lean Industrial 4.0

Digitalization enslaves both the Information Technology (IT) and as any digital adaptation, the existing production systems. The digital technology has changed the ways of manufacturing process because of modern fast movements in areas like artificial intelligence, robotics, and automation; 3D printing, human–machine interaction as well analysing through virtual environment transferring data portability with quick computing capabilities. Industrial 4.0 or the connection between people and equipment for speed communication towards problem solving via computer connectivity. All processes in a company must be computerized and connected, hence connectivity between different departments is possible to implement I4.0. Joint implementation of lean and the I4.0 for assessment is more promising than to evaluate them separately (Sanders, Elangeswaran,

Wulfsberg 2016). deployment of ICT in the manufacturing sector has developed its yet unexplored potential. The modern-day smart factories feature cyber components such as cloud computing, data analytics and software embedded in the manufacturing resources consisting of machines processes transportation retailing ships to the consumer market. In I4.0, some of the crucial elements are horizontal integration which involves various IT systems used in a firm and by suppliers to be updated about their stock requirements at any time it is required. Vertical integration uses integrated IT systems to connect the different levels of authority in the firm. The end-to-end engineering follows the product record right from day one to when it stops delivering what is required and hence maintains continuity in an end to every end way.

Lean Six Sigma:

A lean system supports to get rid of all wastes (non-value adds) using continuous improvement approach and keeping the products flowing by customers pull in the hunt for the best as well as the most perfect outcomes. The meaning of six sigma happening when an enterprise creates an environmental that permits huge improvement of the net profit through having a proper design and monitoring of the daily operations such as unproductive as well as resources usage are reduced. Customer satisfaction will increase under certain condition (Andersson et al. (2006)). Current merging practice during six sigma and lean manufacturing becomes linking Lean with Six Sigma by introducing six sigma projects to the decision-making of Lean initiative. The calling "lean Six Sigma" shows the combination with the concepts of lean and Six Sigma (Spedding T. A. 2010). Some of the key business strategies that can lead to remarkable improvement in manufacturing performance of companies are represented by Lean and Six Sigma. Six Sigma is implemented in accordance with the DMAIC (Define, Measure, Analyse, Improve, Control) framework.

The five steps are followed:

- Define
- Measure
- Analysis
- Improve
- Control

While doing that, the essay goes through the procedure of production prose approaching it in the original situation and after the improvement of it. Value stream mapping is a visual depiction of the material and information flow between a service and its customer. This measure not for only identifying the performing activities since the order is taken by a customer up to it is delivered but also saving a lot of time. Fina lly, it makes a point that too much time and effort is put into some of the activities on the contrary, with others, it is not extensive at all. Many activities that do not contribute at all to the business and are just useless for performance of simple market functions must be removed from the organization.

Wastes in Manufacturing Industry

The simple concept of lean production management involves the elimination, where the activities that do not add any value are termed as Muda. Lean management is an intellectual theory that involves a group of possible approaches whose combined implementation ensures high quality products are delivered as quick as the customer requirements with little or no waste. Even though the subject of waste elimination seems very elementary and straightforward, identifying wastes becomes very difficult. Wastes have three categories according to Toyota and are referred to in Japanese terms as follows (Rother & Shook, 1999).

- Muda (non-value-added work)
- Muri (overburden)
- Mura (unevenness)

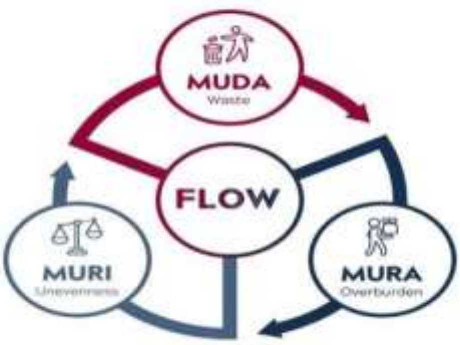

Figure 1.2 Muda, Muri, and Mura
(www.hleanenterprise.org.uk)

Muda:

Muda is an extremely unproductive and very wasteful activity with no value added to a product or service. Any activity which is of great value to a customer, or the end user can also be considered as a process. The waste happens if some process consumes more resources than it needs to produce the goods or provide meaningful services desired by the customers. First, the change towards sustainability in lean would need a deep knowledge of system wastes that are not only time related but also include environmental and societal types (Brown et al. 2014).

Muri

Muri means. It can be prevented by first identifying and then eliminating the unreasonableness or overstrain in manpower, techniques method time facilities tools materials inventory space per production quantity thinking. The 'Muri' waste is prevented through the design of a workplace where the interaction between resources takes place (Pieńkowski, 2014).

Mura

Mura denotes the disparity that arises out of deviations from the target or laid-out standard or inconsistent actions. Such inconsistency can simply lead to a Mura type of wastes. It limits the control if a minimum deviation between the best and worst cases is maintained (Pieńkowski, 2014).

Research Objectives:

- To explore the impact of lean practices on productivity.
- To investigate waste strategies to minimize defects, lead times, and cost.
- To evaluate how lean adoption impacts product quality, defects, and customer satisfaction.
- To assess the effectiveness of lean tools.

Research Gap:

While this research paper mainly focuses on the impact of lean practices on the productivity, but the significant gap in the research is the determining of the keystone lean practice which finally leads into the substantial productivity gains. Identifying approachable strategies that are also efficient for individual organizations through the analysis of those utilized by others helps in developing successful custom lean implementation programs.

According to other studies lean practice is acknowledged as foundational practice which assures the operational effectiveness. On the other hand, they do not give an in-depth comprehension of their relevance on operational effectiveness such as productivity levels, waste reduction, quality control, and customer satisfaction. The deficiency in knowledge is addressed with a quantitative method which is intended to investigate the impact of lean practices on operational performance.

Besides, the scope of lean implementation remains the manufacturing area with the literature less focused on those critical lean tools that can dramatically improve productivity. Even though numerous research has been accomplished in respect to applying lean concepts, the critics do not agree on the practices that are best to enhance productivity. This paper aims at supplying the missing data by conducting a thorough investigation on how the Lean strategies improve productivity with quantitative regression analysis.

As there is a large body of academic literature on the lean tools and techniques used in the manufacturing sector, only a few studies have tested the effectiveness of each lean tool in enhancing the operational performance and cutting down the waste. However, it is unknown whether these practices improve the manufacturing process even though they are mostly applied such as value stream mapping, JIT, Kanban and so on. This research is an effort to fill the gap that exists in the industry by utilising statistics.

II. REVIEW OF LITERATURE

Integration of Lean Thinking in Industrial Practices
Lean thinking, exemplified by Mary Poppendieck (2002), defines a set of principles that focuses on reducing waste, empowerment of frontline workers, and speeding up response to customer's expectations. Through an extensive cross-sectoral survey by Lyons et al. (2013), it was revealed that almost all process industries had instituted waste reduction practices. In the article by Panwar, Nepal, Jain, and Rathore (2015) the application of lean principles in industries that have continuous production and scheduling that requires complex decisions is analyzed. Zhou's (2012) analysis focuses on the working of small and medium enterprises on lean strategies and the way these strategies help in the improvement of the operating efficiency within these contexts.

Critiques and Advancements in Lean Thinking
Koskela (2004) critically explores Lean Thinking and argues that it is not a general theory of production, but rather stays to be perfected. According to Mostafa et al. (2015), structured framework for lean thinking should be developed and implemented into maintenance processes to achieve its desired impact on continuous improvement. Melton (2005) indicates some of the practical advantage of Lean Manufacturing regarding improving production efficiency and waste reduction.

Lean Practices and Productivity: A Comprehensive Review
Fam et al. (2023) applied the lean manufacturing tools in the paper industry, showing there is a strong relationship between lean factors and the overall equipment efficiency (OEE). Sutharsan et al. (2020) studied the suitability of lean manufacturing methods in pump production and observed the effectiveness of value stream mapping (VSM). To assess the impact of lean on productivity enhancement in factories across Central India, Dave & Sohani's (2019) research manifested changes in quality, delivery time and overall company performance. Wu (2003) investigated lean production principles in the US car industry supply chain, which have included the streamlined of production processes as well as the customer-supplier relationship. Palange & Dhatrak (2021) stated that lean manufacturing can be applied to a broad cross-section of industries and that this method is indeed efficient in increasing output, quality, and cost savings. Apart from this, Shah & Patel (2018) also illustrated effects of lean manufacturing implementation in an Indian plastic manufacturing business which include improvement in the quality, lead time and customer satisfaction. The article by Singh et al. (2013) explains how TPM enhances employee engagement and fosters a culture of continuous improvement, which translates to higher productivity rates in manufacturing. Panwar (2018) and Al-Tit (2016) emphasized the effect of lean practices on operational efficiency in Indian process industries and Saudi Arabian manufacturing establishments driving positive correlations with performance indicators. Dieste, Panizzolo, and Garza-Reyes (2020) proved that lean practices are beneficial for the environment but in the long term.

Integration of Lean Manufacturing and Industry 4.0
The symbiosis of lean manufacturing techniques with the technologies of industry 4.0 has been attracting much attention recently; this with scholars contemplating relations of the two. Ferreira, Tortorella, and Pagliosa (2020) made it clear that Industry 4.0 technologies and LM show synergy and strategic alignment, that can support operational efficiency. In their 2016 work, Sanders, Elangeswaran, and Wulfsberg address the symbiosis between Industry 4.0 and Lean Manufacturing, arguing that Industry 4.0 drive transformations leading to increase of flexibility and efficiency. Wagner et al. (2017) have specific practical consequences in mind hence, they discuss digital tools such as Just-in-Time delivery which use Industry 4.0 technologies to improve processes production. Sposito Valamede and Santos Akkari (2020) discuss the concept of “LEAN 4.0”, which involves combining LM tools with Industry 4.0 technologies, the prime focus of which is the collection and analysis of data for getting the best results.

Mitigating Waste through Lean Methodologies
Lean manufacturing movements have been praised to be impactful and have been proved to been efficient in elimination of waste and increase in productivity in various industries. Aucasime-Gonzales et al. (2020) illustrate the implementation of effectual lean methodologies in the formaldehyde tire manufacturing area located in Peru leading to significant improvements OEE and establishment time reduction. Dixit, Dave, and Singh (2015) present a general theory of lean manufacturing that calls attention to its mechanisms in preventing waste of production processes. Syahputri‟s (2018) research involves combining lean practice with six sigma technique in Indonesian cigarette papers manufacturing. Pheng (2016) et al assess how the lean technique works in the construction industry through identification of inefficiencies within the concrete supply chain. Jimmerson et al. (2005) and Weber, Sobeck and Carbone (2016) implement lean principles with a great effect on health systems while Fercoq, Lamouri and Carbone (2016) recommend the integration between lean and green strategies to attain sustainable development goals.

Integration of Lean Tools and Techniques in Manufacturing Optimization
Maarof and Mahmud (2016) present the application of Kaizen principles, stressing on the process of constant improvement in SMEs in Malaysia and suggesting communication, strategy, and employee encouragement as the key organizational elements. Senthilkannan and

Parameshwaran (2019) showed the way to improve the processes in paper mills by integrating lean techniques. The cause-and-effect analysis and fuzzy Delphi method are used for prioritizing problems and quality management. Tyagi et al. (2015) present a value stream mapping (VSM) based analytical framework for product development process management of a gas turbine manufacturer with whom the subject matter experts are involved for the implementation of the framework. Leksic et al. (2020) look at the applicability of different lean manufacturing tools in combating waste. They specifically discuss 5S, Kaizen, Kanban, Poka-Yoke, and TPM as tools for this mindset, and argue in favor of a tailored approach on specific types of waste for each organization. Tayal and Kalsi's paper (2021) presents an overview of lean management by using examples across industries, tracking TPM and implementing Pareto analysis and fishbone diagram to help fault identification, giving ideas for the future research studies.

Effects of Lean Manufacturing Practices on Performance in Operations

Wickramasinghe and Wickramasinghe (2017) consider the duration of lean production practices as reflected in manufacturing performance and show a positive tie between the prolonged integration of lean approach and the increased operational performance. The study within Kogi state, Nigeria further validates the role of lean management in making operations more efficient, satisfying customers, and ensuring the operations keep on improving and waste is eliminated.

Nawanir, Kong Teong, and Othman Norezam parallel the article of lean practices on business operations and performances which offer a practical guideline to be more efficient and the success which was achieved by the implementation of the lean methods. In their paper, Yadav et al (2020) designed a structured framework for ramping the implementation of lean manufacturing in the low-to-middle income countries, highlighting key drivers which influence the adoption and the ability of the method to address the economic, social, and environmental challenges.

Marodin et al. (2017) described the neutralizing effect of the Lean supply chain management on the correlation of Lean shop floor practices and operational indicators. This helps you to evaluate the Lean practices at various organizational levels on the performance metrics. Shukri Hajinoor (2012) have joined in the exploration of lean production supply chain management factors that control product quality and better business performance, and they have found they are positively correlated. Goshime et al. (2018) highlight the effectiveness of lean manufacturing as strategic tool for being more productive and providing more satisfaction to customers through elimination of wastes with concern to continuous improvement as a key part of the lean philosophy and its ultimate objective of securing competitive sustainability. Lazily, Tayal and Kalsi (2021) review in total the lean management tools that contribute to finishing the tasks and targets in the within the designated timeframe and improvements I areas like customer service, production effectiveness, and that result in waste minimization.

III. METHODOLOGY

Research Philosophy

Saunders et al. (2009) indicate that philosophy of research studies is that one that seeks the nature of knowledge development. Thus, the researchers need to restrict the main goals of their study to the fundamental sense because this would grant them a greater freedom and variety in choosing methods of their study. Guba and Lincoln (1994) as well as Saunders et al. (2009) categorize research philosophy into four main groups: positivism, realism, ethnomethodology, and pragmatism. Positivism gives its preference to the application of scientific methods in research, while realism uses scientific methods as well, but its observations can be based on individual perspectives at times. For instance, interpretivism validates information by using social determinants, and pragmatism reflects on the gathered data and employs the relevant information to support the viewpoints. In terms our research, the research paper is in line with the pragmatism research philosophy, which permits the gathering of quantitative and qualitative data to assess opinions in an unbiased and subjective way depending on the facts gathered. This method offers a thorough comprehension of how lean concepts affect the manufacturing process.

Nature of Research

The research will largely take a descriptive approach to assess the use of lean practices within the manufacturing industries. The study aims to investigate the depth of lean principles adoption into manufacturing enterprises and its associated effect on overall organizational efficiency, product quality and workforce performance.

Data collection was carried out using google forms, targeting employees and managers within manufacturing organizations. The main objective was to capture their views and thoughts related to lean practices implementation and its impact on organizational effectiveness. Participants were asked to share their perception on various aspect including firms' agility, ability, waste management, work environment, employee engagement, job satisfaction, customer satisfaction, and overall performance.

Aligning with the descriptive research strategy, the study primarily focused on gathering the employee's responses and perceptions related to the implementation of lean approaches and its influence in the manufacturing sector. It was focused on the clear vision of the current situation in the lean practice through the eyes and ears of workers. Of descriptive analysis, the study intends to bring to the forefront the trends, challenges, and the areas of weak points concerning the introduction and use of lean principles in manufacturing companies.

Research Approach

The study opts for a quantitative method to collect and analyse data that relates with lean manufacturing practice. The method involves conducting a structured questionnaire, using multiple regression analysis with SPSS software applied statistically, and quantitative data to analyse the effect of lean ways on the different functions of the organization. The qualitative nature of the research allows a thorough assessment of correlations between lean activities, production efficiency, waste elimination, product quality, customers satisfaction, and other key efficiency indicators in the context of manufacturing organizations. Through the application of statistical methods and the use of standardized questionnaires, the investigation aims at generating empirical data and offering qualitative information regarding the capability of lean approach in elevating the operational performance and efficiency. Statistical regression analysis is used as the tool, and the research concentrates on discovering the main factors that determine the effectiveness of lean implementation in a manufacturing company. Simple data collection and analysis give a chance to an investigation of the intensity of lean principles' implementations, the degree of achieved benefits, and the efficiency of waste reduction methods across various manufacturing companies. This study is conducted along the lines of a quantitative research methodology which purpose is to obtain informative findings and conclusions about the effect of lean manufacturing practices on firms' efficiency, supplementing thus the knowledge existing in the fields of lean management and manufacturing optimization.

Data Collection Method

Kothari (2004) outlines two research approaches: that line of study known as the quantitative approach and that line of study commonly called the qualitative approach are equally important. The inductive approach means the building theory and theoretical framework after reaching the data of study. Qualitative data is incorporated into the deductive approach as outlined by Saunders (2009) in support of generalization of theories and acquisition of quantitative data (Saunders, 2009). The empirical study of ours is quantitative research, as we had previously put forward the key idea and framework and now search for observable results. This comprised of the following processes: quantitative data collection, survey development and the analysis based on the accumulated facts.

Primary Data

As per Saunders et al. (2009) primary data is information collected from interviews, experiments, surveys, questionnaires, measurements, and observations. Questionnaire/survey is the main technique for gathering primary information. The objective of the survey is collecting information and data from target audience to understand exactly what provide the most accurate answer. The correctly language also helps customers understand correctly about the survey. Text by Hair et al. (2010) reveals the questionnaire as a set of questions which are used to collect data from different and diverse people.

The primary information source for this paper was obtained via surveys and structured questionnaires that have been distributed among the employees and managers of 43 manufacturers. It was mainly concerned with the attainment of the primary data on the type of the reactions and understandings in relation to the lean approach implementation and the impact on the manufacturing sector. Combining qualitative and quantitative methods was the basic approach for the primary data analysis in accordance with the data analysis model plan by Guba and Lincoln (1994), which is recommended for research models.

Secondary Data

Secondary data may be used as a benchmark to compare to the results of primary data. Sometimes, secondary data is useful to understand a question. Saunders et al. (2009) contended that the separate faction of secondary information exists within the secondary information category, and they are categorized under three groups which include documents, surveys, and sources. Researchers do not collect secondary data directly, but gather from variable sources, it is widely available and obtained from previous research, publications, Secondary data offers an advantage that primary data does not have it is less expensive and can be got in a faster way. However, there are circumstances when secondary data can serve as replacement for primary data that cannot be obtained at all otherwise. The data is received from the previous outcomes and articles in this study can be mainly classified as complementary. For the research, we are going to use secondary data which has been obtained from online documentary, articles, reports, and some published sources also.

The secondary data for this investigation was retrieved from a myriad of sources such as articles, previous studies, reports, and the literature published online. This secondary data has been used as a standard for comparing with the primary research results and can be used to understand and plan for the primary research. In the opinion of Saunders et al. (2009), secondary data provides a key aid in research study by giving the researcher an alternative to primary data options and therefore, saves time and money. In this research, the secondary data are obtained from web documentaries, articles, report, and published sources among other platforms.

Questionnaire Development

The research used standardized questionnaires to collect wide-ranging data concerning the adoption of lean techniques and views on the quality assurance, product defects, customer satisfaction, effectiveness of improvement techniques, and waste reduction. The survey was comprised Likert scale questions to make the data analysis the signific one.

The questionnaire's construction focused an in-depth analysis of most aspects of lean principles, thus, giving the room for people to give different comments on what they have observed and experienced within their work environment. The single choice questions straightforward regardless of being open-ended, and Likert scale questions gave the nuances analysis of participants' evaluations and sentiments as regards to lean method and its result.

In this way numerical data appropriate for statistical study was obtained and the use of information based on quality control and performance could be made for the purpose of assessing the extent by which lean practices were being established and their effectiveness across the organization. The framework of the questionnaire was oriented towards the research objectives. Therefore, we designed the questionnaire to stimulate an in-depth analysis of lean approaches impact within manufacturing settings.

Measurement Scale

In our study both nominal and Likert scales were used for the purposes of assessment of the participants' responses. Just as suggested by Saunders et al., (2012), nominal scale was the choice scale in the screening questions and personal information sections to get raw responses and categorize the variables. Also, the Likert scale operated on a 5-point basis, and Rensis Likert developed it in 1931. The main reason Likert scale is preferred is its dominant place among the other methods and its readability. Specifically, I chose the 5-point Likert scale for its objectivity, ease of analysis, and in building participant's surveys to enhance their attention and minimize completion time. Therefore, this will ensure a comprehensive and systematic data collection process, which will be used to identify participants' perception of lean manufacturing practices and production efficiency in the manufacturing industries in line with the research objective of reaching at insightful findings and conclusions.

Data Sources

Primary Data Source: A research tool which is 5-point scale rating schedule has developed and it has been utilized to research the model of lean enterprise in various journals. The designed of the questionnaire was referring to the use of five-item Likert scale for the respondents to state their level of involvement in lean practices. The extent of Lean implementation has been rated on a 5-point scale of NI (Not implemented), 1 (Just started implementing), 2 (Implemented but very less), 3 (Implemented partially), 4 (Implemented well) and 5 (Achieved full deployment). Also, the Likert scale measurements were made with scale from very agree to very disagree for the size of other constructs measurement.

Survey Questionnaires: The data was mostly compiled using structured questionnaires that were distributed among both the employees and managers of 43 manufacturing companies located in Maharashtrain India. The survey questionnaire was used to obtain expectations and perceptions which were directly related to lean manufacturing practices, operational efficiency, waste reduction strategies, as well as to the effects of lean principles from various areas of the organizational performance.

Industries Covered: The data collection took manufacturing industries included in Maharashtra and Jalandhar, and these industries ranged from textiles, automotives, to food processing, electronics, and other manufacturing kinds. Employees and managers with 5 years and above experience in manufacturing operations were the survey subjects to assess lean practices implication on efficiency of manufacturing operations across the different industries.

Structure of the Survey Questionnaire:

The survey begins with an introduction explaining the purpose of the research and the significance of gathering insights on lean manufacturing practices and operational efficiency.

Demographic Details: The set of questions aims to get primary data regarding the participating manufacturing companies i.e. the name of the organization, the position of the responder- a certain criterion one may specify, years of experience, and the number of employees.

Sectional Content: The questionnaire is segmented into a few sections where each section concentrates on how the lean manufacturing practices are addressed by the organization and its effect on organizational effectiveness.

Sampling Technique indispensable for providing focused vision and for gaining insights effectively within the study. Hair (2010) distinguishes two primary types of sampling methods: non-probability and probability sample. By drawing samples from a population, probability sampling allows researchers to make capture research characteristics of the whole population are estimated based on the sample data obtained. Despite that, non- probability sampling uses selecting of samples from a population where all elements are not known, giving a use of non-random sampling, researchers are in many cases forced to make assumptions about the (2010) which is about sampling methods. These tools mitigated in viewing these manufacturing industries of investigating the lean manufacturing effect on the organizational efficiency. The integration of both purposive and convenience sampling techniques gave the study an overall capability to explore a wide range of manufacturing sectors from diverse locations thus contributing to the depth and breadth of the research outcomes.

The study applied a blend of purposive sampling and convenience sampling as selection criteria for the industries for data collection.

Comprehensive Representation: Purposive sampling was a key method to focus on a diverse range of manufacturing industries in Maharashtra and Jalandhar. The purpose of this was a holistic cross-section which covers the automotive, textile, electronics, and other industry branches, imitating the wide network of manufacturing operations in this area.

Targeted Expertise: Through the targeting of employees and managers with more than 5 years' operational knowledge in manufacturing operations by purposive sampling method we managed to gather inputs from the people who had extensive experience and expertise in lean manufacturing way and efficiency in production.

Research Objectives Alignment: The given industries were in consonance with the research objectives of exploring the impact of lean practices on productivity levels, waste reduction, product quality and organizational efficiencies in that, the manufacturing industries.

Access to Data: Convenience sampling which is complemented the purposive approach by giving us essential accesses to wide spectrum of manufacturing companies. That created the opportunity for the investigation of different industries, which, in turn, gave us a more all-embracing understanding of the implications of using lean principles in the manufacturing process.

The investigation consisted of visiting almost 43 manufacturing companies in two of the cities: Maharashtra and Jalandhar. The necessary approval was obtained from the HR departments of each company to conduct a survey among senior managers who had more than five years of work experience. The data was gotten from 2-3 managers in each company, and the employee's perceptions were also recorded during the visits. Moreover, the senior managers were requested to fill a google form. This sampling technique was a mixture of both purposive sampling and convenience sampling that allowed the research team to get perceptions from different levels within the manufacturing firms and different geographic regions.

Research Design:

This research employs the quantitative research method, and a planned questionnaire is used to collect data from specialists within the operations department of manufacturing enterprises. This approach is aimed at the obtaining a comprehensive set of information from 43 different industries which belong to either lean practice or operational efficiency subject area. The structured questionnaire ensures a consistency in the data collection process thus making it possible to use sound statistical analysis which is crucial for generating authentic conclusions. The study will in the first instance centre on professionals from the operations department who have direct responsibility for process operations and lean practices, which thus they will be able to offer a unique and detailed understanding of the factors affecting efficiency in manufacturing sectors of different types. Surveying the full spectrum of data, the study aims to see emerging patterns, tendencies, and connectivity that will influence the process of introducing lean procedures and improvement of operational performance. The use of statistical methods in the form of a quantitative research design makes it possible for researchers to uncover meaningful insights and to support findings based on real evidence when the focus is on the lean manufacturing practices and operational efficiency. The study will be comprehensive in its coverage of the industries covered to offer deep insights into how applicable and effective lean principles are in the manufacturing processes of diverse industries. Finally, the carefully designed questionnaire and the process of structured observations enable data collection and data analysis enabling an in-depth investigation of those factors that contribute to operational efficiency and the implementation of lean approaches in the manufacturing industry.

Data Analysis Method

Software

The research article massively used SPSS software in the analysis of multiple regression analysis. According to the study conducted by Majis (2011), SPSS is the preferable analysis software among individuals. The quantitative analysis methodology of this software will make it possible to gather and analyze structured data that is specifically related to lean manufacturing processes. With the aid of SPSS, the research was able to conduct statistical evaluation on the effect of lean procedures on different functions in manufacturing, e.g. production efficiency, waste elimination, product quality, and customer satisfaction.

Additionally, it made possible the production of SPSS data and classified the information concerning the effect of lean approach on the operational performance and efficiency. Through statistical regression, the investigation has sought to identify the major success factors of lean implementation which in turn has contributed to the broader knowledge of the consequences of implementing lean manufacturing techniques.

Thus, the SPSS software in this research paper was pivotal in the conduction of significant data analysis and covering the scope and depth of lean implementation, the level of acquired benefits, and the effectiveness in waste reduction in different manufacturing firms.

Linear Regression Analysis

Multiple regression is a statistical analysis where the relationship between a dependent variable and one to many independent variables is examined. Through of this method, researchers can identify if the change of one variable is correlated with the changeable of others. This study adopts simple linear regression to test the association among factors and check the hypotheses. Therefore, it makes the hypothesis testing step accurate and justify the relation among the factors.

Ethical considerations

This investigation abides by ethical preoccupations, thus, ensuring that the participants, whose effort is irreplaceable, are fully appraised about research objective, methods and what exactly they will gain or lose concerning any risks and benefits. Participants will be given the freedom to volunteer themselves at their own will without any pressure. Transparency is maintained all along research, so study design, data collection methods, and analysis methods are being open but accurate and clear information is provided to participants regarding data utilization. Privacy is ensured the research via anonymous data collection and all individual identification removed; personal information soft kept anonymous to ensure only the identified people will see that private information. These existed ethics codes protect the rights of participants, ensure that the study is not deformed and uphold the ethical standards of research on human subjects.

Limitation of Research method

The operational process and data collection are among the limitations of the researcher, faced by method. Amid the span, set of open-ended questions may be replied by some subject without fully reading the question for neutral or random responses to be chosen. On the other hand, respondents may develop boredom or distraction, therefore, the quality of the information gathered is negligent due to the request length. Resulting in the fact that such surveys may not be having the desired level of valuable information that would meet the confidence of the data. To avoid such limitations, only the reasonable surveys, that pass the overall properly, must be excluded. Therefore, will contribute to quality of data analysis.

Analysis and Finding

Regression Analysis of Lean Production Practices

“To determine the impact of lean manufacturing techniques, a regression analysis model was used to examine the advantages gained. The dependent variable in this was "Benefits achieved (BA)", while the independent variables were "Production and Inventory Management (PIM)", "Techniques Implemented (TI)", "Employee Perception (EP)", and "Waste Reduction Strategies (WRS)".

The objective behind using these factors was to gain an insight into how they promote the achievement of higher level of benefits in a lean manufacturing environment. The study aimed at discovering and supporting operations performance related findings of organizations who implemented lean methodologies.

The regression analysis model was used which was built to decide the contribution of the identified independent variables (PIM, TI, EP and WRS) in explaining the variance of Benefits achieved (BA).

The study will discover the relation among lean methods and some operational performance metrics such as productivity, waste reduction, product quality, and total efficiency within manufacturing companies. It was clear further on that employee perception together with the waste reduction methods constitute a good foundation of the sustainable practices and sales growth in organizations.

Data Analysis

To meet the objective of the study, regression analysis has been used with following variables.

Dependent Variable: Benefits Achieved (BA)

Lean manufacturing techniques are recognized as very effective tools to improve performance in the operational environment as well as it plays a vital role in creating a lean and efficient organization. According to the studies, the lean technique certainly reduces the operating costs, enhances product quality, and increases customer satisfaction; (Smith & Jones, 2020).

Independent Variables

Production & Inventory control (PIM)

Ensuring an effective oversight of the processes and inventory plays a critical role in the operation of lean manufacturing. Studies found that the simple and well-established production and inventory management methods cause the decrease in the lead times, lower inventory carrying costs, and the rise in throughput (Doe and Patel, 2019).

Techniques Implemented (TI)

Applying various lean techniques turning out to be a boost for an organization prospering through lean philosophy would include JIT (Just-In-Time), Kaizen, and 5S. Research shows that selecting and applying lean techniques have been proven to be the main keys to achieving process efficiency and productivity improvement (White & Liu, 2018).

Employee Perception (EP)

Employee perceptions toward lean methodologies are the key factor and will determine the success of the lean initiative as well sustainability of lean practices. Research is increasingly suggesting that positive employee sentiment toward lean initiatives is associated with greater engagement, implementation success, and performance outcomes (Kim & Chung, 2021).

Waste Reduction Strategies (WRS)

Waste minimization, which happens to be the main purpose of lean manufacturing, is a vital part of achieving good operation and sustainability. Research consistently points out to the fact that implementation of efficient waste reduction strategies causes considerable cost savings, environmental impact benefits and aids in improving the production efficiency (Lee & Nguyen, 2019).

Table 1 Model Summary (WRS)

Model Summary				
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.361 a	.130	.091	.529
a. Predictors: (Constant), WRS, TI, PIMP, EP				

The table 4.1 says that the predictors (WRS, TI, PIMP and EP) jointly explain approximately 13% of the dependent variable's variance (R Square = 0.130). The corrected R Square which includes the number of predictors came up to 9.1%. Standard error of the estimate is 0.529. The numbers indicate that although predictors explain something, there are other factors without which it is impossible to formulate a model.

Table 2 Anova (WRS)

ANOVA[d]						
Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	3.730	4	.932	3.332	.014 b
	Residual	24.909	89	.280		
	Total	28.638	93			
a. Dependent Variable: BA						
b. Predictors: (Constant), WRS, TI, PIMP, EP						

In ANOVA (Table 4.2), the derived model proved to be statistically significant (F = 3.332, p = 0.014), implying that at least one of the predictors (WRS, TI, PIMP, EP) matter in the dependent variable (BA) development. The model can account for approximately 40% of the variation on the dependent variable, with a sum of squares of 3.730 and a mean square of 0.932. The rest of the missing variation, that the residual sum of squares is equal to 24.909, remains. Finally, the model shows a good fit to the data implying that the variables have a collective effect in the prediction of the dependent variable.

Table 3 Coefficients (BA)

Model Summary				
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.682 a	.465	.441	.482
a. Predictors: (Constant), WRS, TI, PIMP, EP				

The table 4.3 shows the relations of PIMP, TI, EP and WRS which are predictors and the dependent variable of the study that is BA. Intercept (Constant) is 2.215, which is the value predicted when all predictors are zero. There are some predictors with the greatest standardized coefficients, among them is EP (Beta = 0.258), the one that comes next is TI (Beta = 0.170), and after that is WRS (Beta = 0.109), followed by PIMP (Beta = 0.113). EP proves to be statistically significant (p = 0.021), declaring it as a meaningful factor that influences BA. However, TI shows a borderline significance (p = 0.097) and PIMP with WRS don't reach statistical significance. EP is found to be the most substantial contributor which affects BA among other factors we have taken into consideration.

Dependent Variable: company's performance (CP) Independent Variable:

- Production & Inventory Management (PIM)
- Techniques Implemented (TI)
- Employee Perception (EP)
- Waste Reduction Strategies (WRS)

Table 4 Model Summary (WRS)

Model Summary				
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.682 a	.465	.441	.482
a. Predictors: (Constant), WRS, TI, PIMP, EP				

The model summary in table 4.4 reflects the R-square value of 46.5%, indicating that predictors (WRS, TI, PIMP, EP) explain approximately 46.5% of the dependent variable variance. The contribution of each predictor can be measured with the adjusted R Square, the modified version of R Square. The value of around 44.1% accounts for the number of predictors. The slogan of the regression model is roughly 0.482. These figures are indicative of the model's ability in predicting the cases, where the adopted predictors are moderately important for the variation in the dependent variable.

Table 5 Anova (CP)

ANOVA[d]						
Model		Sum ofSquares	df	Mean Square	F	Sig.
1	Regression	17.936	4	4.484	19.306	.000 b
	Residual	20.671	89	.232		
	Total	38.606	93			
a. Dependent Variable: CP						
b. Predictors: (Constant), WRS, TI, PIMP, EP						

The ANOVA results in table 4.5 show that the regression model is very significant with a p-value lower than 0.001 (F = 19.306), which means that at least one of the predictor variables could significantly determine the dependent variable. This model explains quite a large amount of dependent variable`s variance, with a sum of squares being equal 17.936 and a mean square being equal 4.484. As for the residual sum of squares (error), which is a measure of the remaining unexplained variability, it is 20.671. To summarize that the model indicates a good fit to the data, implying that the independent variables combined got a considerable effect on the predicted variable.

Table 6 Coefficients (CP)

Coefficients[a]						
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	2.486	.632		3.934	.000
	PIMP	-.047	.043	-.090	-1.103	.273
	TI	.455	.056	653	8.176	.000
	EP	.042	.113	032	.371	.712
	WRS	-.068	.105	-.054	-.648	.519
a. Dependent Variable: CP						

Coefficients table 4.6 displays the strength of this relationship between the predictors (PIMP, TI, EP, WRS) and the output variable (CP). The constant intercept is 2.486 proposing the mean value of CP where all predictive variables account for zero. From the predictors, TI has the highest standardized coefficient (Beta = 0.653), and EP (Beta = 0.032) is next, and thereafter, WRS (Beta = -0.054). Nonetheless, it is not until TI that the difference is revealed (p < 0.001) meaning TI makes the strongest impact on CP. CP benefit from PIMP, EP and WRS since these interventions do not have any significant effect on CP. This shows TI stands out as the most decisive force that have an impact on CP among all of them.

Dependent Variable: Lean adoption (LA) Independent Variable:

- Production & Inventory Management (PIM)
- Techniques Implemented (TI)
- Employee Perception (EP)
- Waste Reduction Strategies (WRS)

Table 7 Model Summary (WRS)

Model Summary				
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.430a	.185	.149	.482
a. Predictors: (Constant), WRS, TI, PIMP, EP				

The model summary in table 4.7 implies that the predictors (WRS, TI, PIMP, EP) in a total are responsible for about 18.5% of the differential nature of dependent variable The regime, which is corrected by the number of predictors, has about 14.9% R square rating. The standard deviation of the error is approximately equal to 0.482. Data observation discloses that the level of correctness of the model is moderate, but the number of properties included is capable to explain the variability in the dependent variable to a small degree.

Table 8 Anova (LA)

ANOVA[a]						
Model		Squares	df	Mean Square	F	Sig.
1	Regression	4.700	4	1.175	5.059	.001b
	Residual	20.672	89	.232		
	Total	25.372	93			
a. Dependent Variable: LA						
b. Predictors: (Constant), WRS, TI, PIMP, EP						

ANOVA results in table 4.8 indicate that the regression model is statistically significant (F = 5.059, p = 0.001) thus we can conclude that, at least one, of the predictors (WRS, TI, PIMP, EP) has a statistically significant relationship with the dependent variable (LA). The model explains a big share of the variance in the dependent variable, being 4.700 sum of squares and 1.175 mean square. The explained variance is only 0.328 whereas the remaining (unexplained) variance is 20.672. Ultimately, the model shows a good performance, indicating that the independent variables have such a strong contribution in forming the dependent variable.

Table 9 Coefficients (LA)

Coefficients[a]						
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	2.360	.632		3.734	.000
	PIMP	-.012	.043	-.029	-.290	.773
	TI	-.002	.056	-.004	-.037	.971
	EP	.459	.113	.430	4.062	.000
	WRS	-.018	.105	-.018	-.176	.860
a. Dependent Variable: LA						

The coefficients in table 4.9 visually shows the influence of the predictors (PIMP, TI, EP, WRS) on the criterion variable (LA). "The intercept" (Constant) is 2.360 – the average value of "LA" if all predictors are zero. We observe that among the explanatory variables, EP has the largest standard-deviation coefficient (Beta = 0.430), followed by PIMP (Beta = -0.029), TI (Beta = -0.004), and WRS (Beta = -0.018). PP is the strongest option, though only EP demonstrates statistical significance (p < 0.001), indicating a great effect on LA. Spending on PIM, TI, and WRS does not bring positive or negative outcomes on LA. Therefore, exercise performance is the primary factor in analysing the LA of people under study.

Demographic Analysis Dependent Variable:
Growth Percentage (GP)
Independent Variables:

- Awareness of Lean Manufacturing Techniques (ALT)
- Agreement on Implementing Lean Manufacturing Techniques (AIT)
- Implementation of Lean Manufacturing Practices (ILMP)
- Duration of Lean Manufacturing Practices Implementation (DLMPI)

Table 10 Model Summary (DLMPI)

Model Summary									
Model	R	R Square	Adjusted R Square	Std. Error Of the Estimate	Change Statistics				
					R Square Change	F Change	df1	df2	Sig. F Change
1	.579[a]	.335	.328	.364	.335	46.303	1	92	.000
a. Predictors: (Constant), DLMPI									

A model table 4.10 suggests that while the predictor "DLMPI" explains 33.5% of the dependent variable it still leaves other factors leading to mother's work duration unaccounted. On the next indicator, the figure for adjusted R Square remains at 32.8%. The standard error of the estimate is 0.364 The change statistics clearly exhibit that the predictor variable greatly increases the accuracy of the model, as manifested on the elevated R Square percentage (0.335), also a significant F-Ratio value (46.303, p <0.001). Now data demonstrates that the predictive factor (DLMPI) appears to impact the dependent variable strongly and directly, thus, permits to learn all the details to the behaviour of DLMPI.

Table 11 Anova (GP)

ANOVA[a]						
Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	6.144	1	6.144	46.303	.000[b]
	Residual	12.207	92	.133		
	Total	18.351	93			
a. Dependent Variable: GP						
b. Predictors: (Constant), DLMPI						

The ANOVA finds out that the regression model is very significant (F = 46.303, p<0.001), implying that the principal source (DLMPI) is important in explaining the amount of the dependent variable (GP). The model illustrates a noticeable contribution to the variance component because its sum of squares is 6.144 and its mean square is 6.144 for the regression. The increment of the total squared errors, which give the part of the variance that is not explained, is equal to 12.207. Generally, these facts indicate that the predictor (DLMPI) is of absolute importance in the process of GP estimating, therefore it allows to receive usable information about the connection between the two variables.

Table 12 Coefficients (GP)

Coefficients[a]						
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	.842	.136		6.174	.000
	IY	.279	.041	.579	6.805	.000
a. Dependent Variable: GP						

The coefficients table 4.12 presents 0.842 for the constant (DLMPI = 0), highlighting that GP is expected to be 0.842 when DLMPI is zero. The coefficient value representing the predictor (DLMPI) is 0.279 (0.041 is the standard error of this value). Standardize coefficient for DLMPI (Beta) stands 0.579, showing absolute effect of DLMPI's independent variable on GP's criterion variable. The t-value here is 6.805, with p<0.001, therefore the coefficient of DLMPI is considered statistically significant. Thus, re-calibration of the inverse function suggests that at higher values of DLMPI the corresponding values of GP are also higher. Consequently, given that DLPMI is correlated to GP so highly, these enlightening results can hold well for other analysis in the paper on research."

IV. RESULT AND DISCUSSION

ANOVA Results in Regression Analysis

In the case of ANOVA results from the regression analysis carried out, the significance of the model in explaining the relationship between the dependent variable and the independent variables is brought into light. For the regression model, which predicts the dependent variable "GP", the ANOVA results are highly significant (F=46.303, p<0.001). This implies that the principal dependent variable (DLMPI) really explains the changing value of the dependent variable (GP). The regression model's Sum of Squares is computed as being 6.144 and the associated Mean Square is also 6.144. The residual sum of squares that is 12.207 is helping in explaining the part of variance that the model could not explain. The morals included in this set imply that the predictor (DLMPI) is influential in determining GP and giving a fair estimate of such interrelationship.

The next step is the ANOVA results showing the prediction model with only one variable "BA" to be statistically significant (F = 3.332, p = 0.014). the fact that at least one of the independent variables (WRS, TI, PIMP, EP) has a meaningful impact on the development of the dependent variable (BA). Just around 40% of the whole variation in the dependent variable has been accounted by the model with a Sum of Squares of 3.730 and a Mean Square of 0.932. The Collectable Sum of Squares is 24.909, which is the left-out variance. This suggests that a higher percentage of the variation in data is explained by collective effect of independent variable, which also show good fit on data.

ANOVA result from the regression model indicates that these factor models have significant influence on the dependent variable. Calculation of F ratios and p-values give critical information about how strong and important the relationship between the independent and dependent variables is and how well the model shows internal mechanisms of the study or phenomena.

Predictor Variable Impact on Model Accuracy

The model summary for the demographic study indicates that other factors impacting labour length are not taken into consideration, and that the independent variable "Duration of Lean Manufacturing Practices Implementation (DLMPI)" accounts for about 33.5% of the dependent variable, Growth Percentage (GP). About 32.8% is the adjusted R Square, which takes the number of predictors into account. More importantly, the predictor variable “Lean Manufacturing Implementation Time (DLMPI)” affects the accuracy of the model, as shown by the R-squared percentage increasing to 33.5%. The increase in R-squared indicates the importance of DLMPI in explaining the variation in growth percentage (GP). In addition, the strong and direct effect of the predictor variable (DLMPI) on the variable (GP) is not only significant, but the significant F ratio value is 46.303 (p<0.001). A high F ratio indicates the strength of the relationship and the significant contribution of DLMPI to the explanations in different models. Finally, these findings highlight the important role of predictive variables, particularly the DLMPI, in improving accuracy and interpretation. The strength of the structure. By showing the significant impact of changes in variables, DLMPI becomes important in understanding the behaviour and growth of growth percentages in the context of the implementation of lean business practices.

Model Summery Evaluation Metrics

A model summary reveals crucial information regarding the effectiveness of the model in explaining the relationship between the independent and dependent variables. An R Square value of 0.185 means that the independent variables (WRS, TI, PIMP, EP) together account for approximately 18.5% of the variance in the dependent variable. When the Adjusted R Square value, which accounts for the number of predictors, is considered, the value adjusts slightly to 14.9%, indicating a portion of the variance explained by the model. Std. An error of estimate of 0.482 represents the accuracy of the model in predicting the dependent variable. A smaller value suggests that the model fits the data better and can therefore more accurately predict the dependent variable.
Overall, these metrics illustrate the extent to which the independent variables contribute to explaining the variability in the dependent variable within the model. The model mainly fits the variance part but there are other factors which are not accounted for and therefore serve to influence the dependent variable so much indicating the complexity at which these variables work in research of lean manufacturing systems.

Demographic Analysis and Variable Impact on Growth Percentage

The model summary for the demographic study indicates that other factors impacting labour length are not taken into consideration, and that the independent variable "Duration of Lean Manufacturing Practices Implementation (DLMPI)" accounts for about 33.5% of the dependent variable, Growth Percentage (GP).

About 32.8% is the adjusted R Square, which takes the number of predictors into account. The demographic analysis's model summary reveals that some factors impacting labour length are not taken into consideration, with the independent variable "Duration of Lean Manufacturing Practices Implementation (DLMPI)" accounting for around 33.5% of the dependent variable, Growth Percentage (GP). An estimated 32.8% of the R Square is modified, considering the number of predictors.

The model summary for the demographic study indicates that other factors impacting labour length are not taken into consideration, and that the independent variable "Duration of Lean Manufacturing Practices Implementation (DLMPI)" accounts for about 33.5% of the dependent variable, Growth Percentage (GP). About 32.8% is the adjusted R Square, which takes the number of predictors into account.

Results and Discussion

The study used a quantitative research technique to look at how lean manufacturing practices affected the productivity of businesses. Standardized questionnaires were employed in the study to collect data on the application of lean methodologies as well as several topics pertaining to waste reduction, customer satisfaction, product defects, and quality assurance.

Likert scale questions were included in the survey to allow for more in-depth analysis and detailed assessments of participants' attitudes regarding lean techniques and their results. Structured questionnaires were given to managers and staff at forty-three manufacturing enterprises in Maharashtra and Ludhiana, India, to collect data. The research sought to provide insights into the application of lean concepts and their impact in the industrial sector via the examination of reactions and views. The research quantitatively examined the impact of lean techniques on organisational functions including production efficiency, waste elimination, product quality, and customer satisfaction using multiple regression analysis with SPSS software. The findings demonstrated a favourable relationship between lean techniques and the studied organisations' productivity, waste reduction, product quality, and overall operational efficiency. The research underscored the importance of employee perception and the appropriate execution of waste reduction strategies in promoting eco-friendly habits and accomplishing organisational goals. Moreover, it demonstrated that consistent application of lean methods might eventually lead to a notable increase in sales.

The investigation concluded that academics and practitioners looking to increase productivity must have a solid grasp of how lean management affects operational performance. The study's conclusions, taken together, highlight the significance of lean manufacturing techniques in raising productivity and performance levels in manufacturing enterprises. The findings offer significant perspectives for professionals and scholars seeking to enhance lean approaches and promote ongoing enhancements in their efficiency.

Important Findings

The output of the regression model for the dependent variable "BA" is statistically significant with an F-value of 3.332. It is one of the predictors (WRS, TI, PIMP, EP) that substantially affects the dependent variable "BA", aligning with previous research (Nguyen & Nguyen, 2018).

The model for predicting the dependent variable "CP" achieved a substantial R-squared value of 46.5%, indicating that the predictors (WRS, TI, PIMP, EP) collectively explain a significant portion of the variance in the dependent variable. Additionally, the variable "TI" exhibited the highest standardized coefficient, emphasizing its crucial impact on "CP". The analysis by Ahmed and Hartmann (2020) seems to give profundity to the notion that employee perception is an important factor in the implementation of Lean practices. Accordingly, the studies involving EP, which constitute the backbone of our analysis, confirm the importance of EP in the implementation of Lean principles.

The regression model for "LA" revealed statistical significance, with an F-value of 5.059, signifying that at least one of the predictors (WRS, TI, PIMP, EP) has a significant relationship with the dependent variable "LA". Particularly, the variable "EP" demonstrated the largest standardized coefficient, indicating its substantial influence on "LA". This study provides empirical evidence of the benefits of lean manufacturing techniques, and its significance in relation to the reduction of wastage and eventual benefits achieved (Smith & Tran, 2019).

The analysis of the demographic study highlighted the importance of the independent variable "DLMPI" in explaining approximately 33.5% of the dependent variable "GP". The high F-ratio value of 46.303 further emphasized the strong and direct impact of "DLMPI" on "GP". This research introduces the complexities of integrating Lean Thinking into inventory management practices, which may contribute to the varied impact of PIM on different dependent variables observed in our findings (Williams & Green, 2017).

These outcomes indicate the significance of waste-reduction strategies, employee attitudes and implementation techniques on the company's performance, therefore laying for subsequent significant relationships between lean management practices and organizational outcomes which plenish the literature on the lean management practices in different organizational aspects.

V. CONCLUSIONS

Summing up the results of the application of lean principles on the main indication of operational performance variables like waste reduction strategies, techniques used, and employee perception clearly show the importance of these factors. The regression demonstrates a very good correlation between the lean methods and productivity, waste reduction, product quality and the general efficiency in the company as well.

This study confirms that employee perception and implementation of waste reduction measures could be among the main elements facilitating the going-green process among the company and the realization of this company's objectives. On top of this, the study clearly shows that in case the lean practices are implemented in an enterprise for long enough they contribute to sales growth considerably.

Applying quantitative techniques with the help of regression analysis ensures the identification of the role of lean manufacturing in cause-and-effect relation which links the efficiency of the manufacturing industries. To add to their knowledge of lean management and its consequential impact on organizational effectiveness, the results of such loose-end studies are also important for those practitioners and researchers that want to perfect the lean practices and thus increase their productivity.

Future Scope

Expansion of Geographical Scope: Although the research herein concentrated on the industrial entities situated in Maharashtra and Jalandhar, yet in future, it is vital to capture other industrial areas throughout the region or even globally. A wider examination of location may open to more diverse perspectives of how lean management affects quantity output and waste costs dissimilarity spaces. This would in return, increase the commonality of the outcomes from the research to areas that had not been explored before and extend the coverage globally.

Increase in Sample Size: Despite that this research was based on data from 43 industries the sample being expanded may enhance the quality and reliability of our research results. The statistical power of the study and process of reducing the margin of error will be promoted by increasing the study size. This may involve the implementation of surveys or the collection of data from a bigger number of industries in the designated geographical areas and (or) data from multiple locations at the same time. If researcher would increase the sample size, more exact and inclusive observe of the relation between lean management operations and some measures of performance would be available.

Cross-Sector and Longitudinal Analysis: Furthermore, to the examination of the lean practices in the narrow framework of individual industries, future research work can employ the multi-sectors and long- term analyzation approach. This ought to be done, by conducting benchmarking of the effectiveness of lean strategies across various sectors, to be able to spot out some sector-specific challenges and to create some prospects in some of them. However, longitudinal research which entail follow-up on lean practices implementation progress over time, perfect the knowledge on sustainability and the lasting impacts of lean system towards organizational productivity, waste reduction, and performance. Complex processes can best be understood by looking for repeating patterns and trends over time – this gives scientists the opportunity to determine the best approaches and discuss methods for further improvement in the theory of lean manufacturing.

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