

Lean Manufacturing's Impact on Process Industries

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Abstract

A mature and well-established topic for debate, lean management system has been highly regarded in the manufacturing sectors for the past 50 years. The theory behind this study was developed mostly from high-impact scholarly publications, including theses, books, journals, conferences, and other online resources on the topics of LM. Lean manufacturing's primary goals are to increase value for the client, cut waste along the whole value chain, and foster an environment where continuous improvement is valued. Investigating several LM case studies that have been published in various process industry sectors is the research strategy utilised to evaluate these theories. The study highlights the significance of the unique production process features of each facility implementing lean as well as the variety of advantages and expectations that may be seen upon successfully implementing the most effective LM methods. The importance of an on-going organisational commitment to the implementation of LM is also brought to light. While the implementation and results of LM were the focus of this article, it would be interesting to look at the reasons that prevent successful adoption in process industries.

Keywords: Lean Manufacturing, Industry, implementation, Customer, Global economic

1. Introduction

India is quickly rising to the top of the list of preferred manufacturing locations in the world. Along with creating a wealth of opportunities, India's transition to a global manufacturing powerhouse has increased competitiveness for Indian process industries on both a local and worldwide scale [1]. These industries must overcome a number of obstacles to be competitive in today's changing marketplace. Improving supply chain performance and manufacturing efficiency are two major concerns. The start of the world economic crisis occurred ten years ago in 2018. Due to the collapse of both industrial output and consumer demand throughout

this decade, the worldwide market was greatly unstable [2]. According to a representative from the chemical industry, a singular occurrence left businesses with significant amounts of inventory that they were unable to get rid of because of quickly declining sales. Nowadays, firms all over the globe have adopted and imitated lean manufacturing ideas as a result of the success of lean manufacturers in Japan, the US, and Europe in becoming world-class manufacturers. Lean manufacturing experiences over the past three decades have mostly come from wealthy nations like the US, UK, and Japan. The Toyota Production System (TPS), which was first presented in the middle of the 20th century to define the automobile production process at the Toyota Motor Company's facility in Nayoga, Japan, is when the notion of LM first came into existence. The machine that changed the world was a ground-breaking book by [3] that established and described the contemporary framework of lean manufacturing, which has been widely implemented by numerous industries over the past few decades. What originally began as a process upgrade programme intended to help the Toyota Motor Company increase productivity and profits is now a topic of ongoing research and a production system that is adopted by many industries who wish to take advantage of the benefits of LM such as improved quality delivered, decreased inventory, elimination of waste, and constant process optimization

In light of the aforementioned query, a thorough analysis of the literature enables the preliminary inference that the core goal of lean manufacturing is to improve operations performance through waste removal [4]. The performance that is impacted by operational circumstances was correctly characterised as operations performance. It describes how each production resource level performs and identifies a production system's inherent characteristics. Therefore, it's more likely that wastes (such as excess production, processing, faults, delays, unneeded inventory, transfers, and transportation) were at the operations level as opposed to the business level. Finally, because process industries have special features, adopting lean thinking in them is more difficult than it is in discrete industries. This means that the spread of lean techniques needs to be done carefully for each individual industrial setup. For instance, the lack of separable pieces in process industries makes it difficult and sometimes fruitless to use some lean manufacturing techniques like kanban, pull systems, and cellular manufacturing [5]. Because of this, the main goal of this essay is to offer a theoretical framework for comprehending the basic ideas and practises of lean manufacturing as well as some fundamental principles that either support or contradict a successful outcome following the application of LM principles to process industries. Instead of focusing just on the benefits of LM, this essay provides the reader with a thorough examination of the relevant literature, along with a list of the characteristics that either facilitate or hinder the successful application of LM to process industries.

2. Methods and Materials

The techniques and resources discussed in this chapter were used to develop and support the arguments in this paper problem as well as to test the theories put out in the Literature on theoretical analysis. To check the accuracy of the previously formed hypotheses, a literature survey of scholarly publications is initially carried out. In order to confirm the hypotheses and strengthen the justifications drawn from the earlier journal review,

data is subsequently collected for a particular corporate facility as part of a case study using interpersonal and semi-structured questionnaire interviews. The research technique for this work is shown in Figure 1.

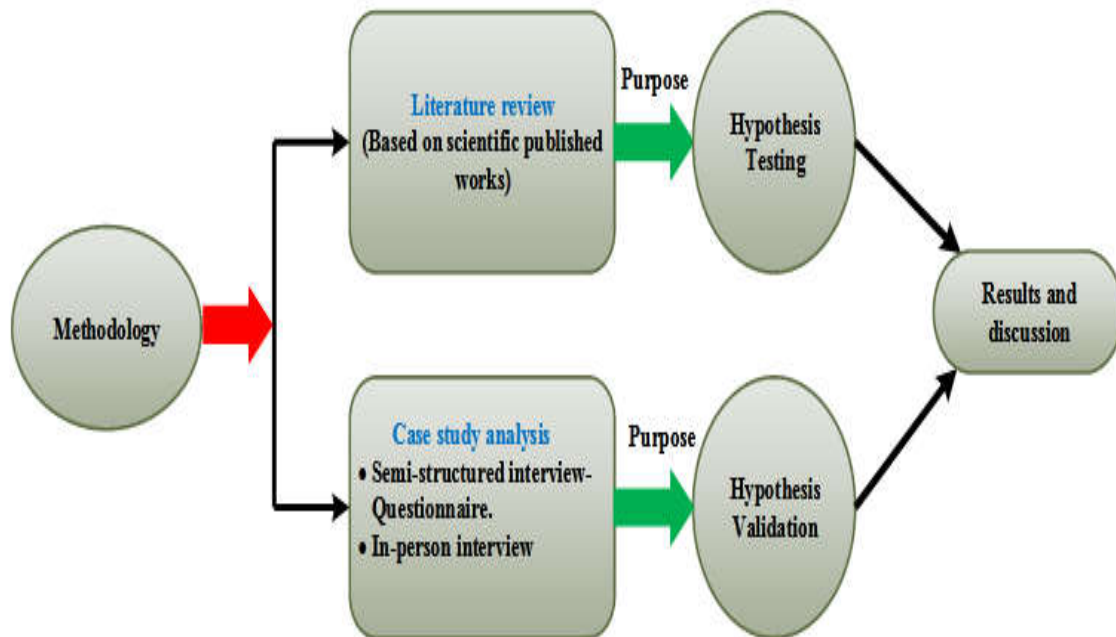


Figure 1 Research Methodology

3. Effects of lean methods on process industry performance improvement

Lean has given applications in a variety of sectors than automotive or discrete manufacturing, such as process, health, and transportation (using the textile industry as an example, it is claimed that lean is transferrable to several industries). Applying lean thinking to many industries, however, is a challenging task, according to [6]. Operational, financial, and environmental factors, for example, can all have an impact on an organization's overall performance. The lean methods are seen to have the greatest influence on operational performance, nevertheless. [7] Provide an explanation of the following six operational performance metrics: productivity, lead time, first pass yield, scrap and rework costs, and unit manufacturing cost. Yet, contends that attempts to increase operational effectiveness also result in decreased inventory and space requirements. Lean manufacturing approaches were said to be able to account for 20% of productivity variations, 24% of manufacturing lead time variations, and 25% of first pass output variations for Indian manufacturing companies. Unexpectedly, TPM was discovered to negatively impact lead times for manufacturing and productivity. The survey's participating plants, according to the study, were elderly and had

just minimal TPM implementation. Unfortunately, the author only looked at the impact of a small number of lean methods on three operational parameters. Yet, several research show conflicting findings about the performance enhancement brought about by the adoption of lean principles. [8] said that as compared to TPM methods, process sectors adopt JIT lean approaches to a lesser level. According to the authors, the process industries' need for high capacity utilisation drives them to use TPM methods. On the other side, it has been stated that JIT procedures improve operational outcomes like delivery and efficiency. Yet, it was shown that JIT supply procedures did not significantly affect productivity or delivery. Similar outcomes are offered by [9]. Regarding the degree of the performance gain from lean, contextual elements like location, kind of production system, and inherent qualities are crucial.

4. Results and Discussions

The distribution of scientific papers from process industries about the use of lean, which were researched for the purpose of this article, is shown year-by-year in Figure 2. Information was gathered from study projects starting in 2000, as was already indicated. Just a small number of research articles have been published before to the year 2000 as a part of scientific works in various periodicals, as shown by [10]. Moreover, since 2010, academics' and practitioners' enthusiasm for the potential applications of LM in the process sector has continuously grown.

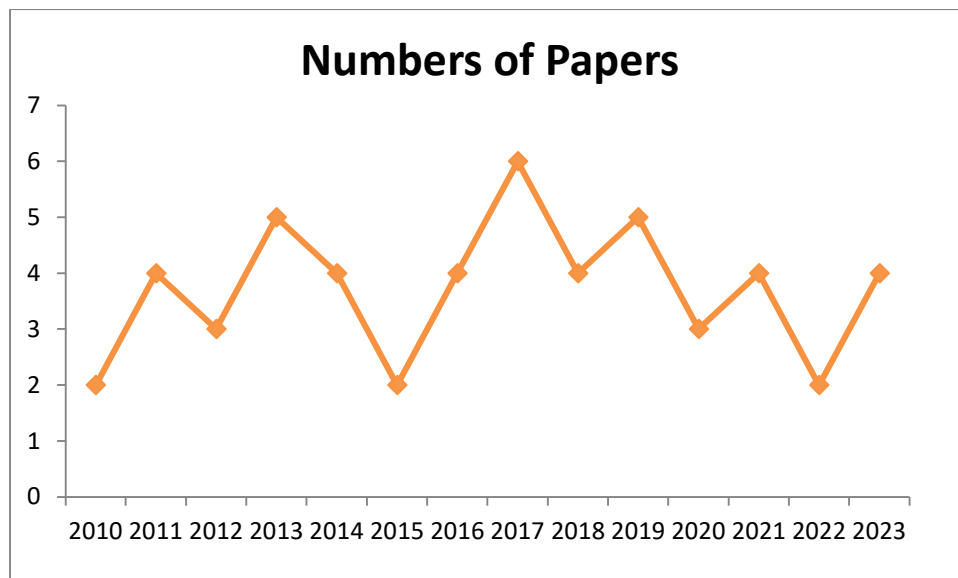


Figure 2. Distribution of year-wise from 2010 onwards

Glass and Ceramics

A total of 76 facilities were examined for the kind of LM tools they used and how much in the research by [11] on the ceramics sector in Spain. The facilities investigated, as reported in this study, create a variety of 100–200 various designs of goods, all of which require the same production facilities. They also only need a limited amount of raw materials. The goods are uniform and made in a consistent manner, becoming distinct from the beginning of the production process, after the moulding stage. According to the analysis's findings, all of the research facilities used Total Productive Maintenance and operational standardisation as their primary techniques. Curiously, despite the costly and cumbersome technology used for the production process being evaluated, not all of the facilities used Single Minute Exchange Die (SMED). Regarding the improvement in performance related to LM, the findings were not all in agreement.

Steel and metal

In their study on the use of lean manufacturing in process industries, [12] provided a case study of the steel mill sector. In comparison to other process industries, the production method used just 3 materials in modest amounts to create coils of steel sheet. The manufacturing is divided into two areas: the hot end and the cold end. The hot end uses dedicated, specialised, and rigid technology, while the cold end uses general-purpose, non-dedicated equipment. After the hot end, or in the midst of the manufacturing process, the product becomes discrete. As specified in this profile, the facility may use SMED, Total Productive Maintenance, and production smoothing.

Table 3. Lean tools' applicability in the steel industry

S.No	Name of tools	Outcome
1	5S (Sort, Set, Shine, Standardize, sustain)	Positive
2	Visual systems	Positive
3	VSM (Value stream mapping)	Positive
4	Setup reduction	Inconclusive
5	JIT (just-in-time)	Inconclusive
6	TPM	Inconclusive
7	Cellular manufacturing	Negative

Textile

A case study-based research project on the adoption of lean principles by the textile sector was done and reported in the work by [13]. Approximately all of these facilities perform the same tasks of cutting, sewing, and weaving and produce a variety of finished products for a wide range of clients. In total, 11 USA-based textile producing facilities were studied specifically for the LM practises employed and the outcome that these effectuated. These facilities ranged in size from small to large in terms of production capacity. The items are produced using specialised, rigid technology, and by the time they reach the final phases of production, they are in a distinct condition. According to the analysis's findings, all facilities used visual control, Value Stream Mapping, one of the initial tools of interest, and 5S. The benefits of lean that the responsible party who was questioned saw included a drop in the amount of raw materials used, a decrease in inventory that, in one facility, reached 50%, shorter changeover times, higher production rates, better quality results, and a reduction in production time. The specified south Indian textile sector uses lean tools including 5S, VSM, Kanban, Kaizen, pokayoke, and visual controls.

Paper and pulp

An LM implementation study for a tissue paper industry that needs the advantage to outperform the competition was conducted in the work published by [14]. The study's goals included cutting down on waste and increasing production. One of the paper mills at the company's second factory, where the study was conducted, produces tissue paper. The firm under investigation is one of the top makers of paper goods in Portugal but also engages in extensive exporting, having a presence in more than 60 countries. The raw materials for this particular product are limited in diversity but plentiful, as is the finished product. The thorough study carried out in this article led to the conclusion that the SMED practise was crucial for this manufacturing line and produced extremely beneficial outcomes, such as an increase in the productive time of 1,5 hours, which translates to yearly profits of over 150.000€. This research demonstrates how using JIT has had a substantial impact on supply chain performance by reducing the paper machine cycle duration and ultimately increasing delivery frequency. The performance improvement graph in this piece of work provides an answer to the query of whether JIT is applicable to the paper industry.

Observations from the case study analyses

The analysis discussed above yields useful information for evaluating the hypotheses introduced in paragraph. Table 2 provides a tabular overview of the findings from the case studies that were examined, enabling a comparative synpaper that will be used later to evaluate these research hypotheses. The features of each manufacturing process are described, along with the results (good, negative, or inconclusive) of applying Lean techniques.

Table 2. Analysis of process industry characteristics and use of LM tools: Summary Table

Industry Sector	Type of process	Stage of discrete product	Types of Lean tools/techniques used	Outcome	Case study Source
Steel and metal	Inflexible	Middle	TPM SMED	Positive	(Abdulmalek, Rajgopal, and Needy, 2006)
Glass and Ceramics	Inflexible	Early	Standardization TPM	Inconclusive	(Bonavia and Marin, 2006)
Textile	Inflexible	Later	Visual Control VSM 5S	Positive	(Hodge, et al., 2011)
Paper & Pulp	Inflexible	Later	JIT MTS	Positive	(Lehtonen and Holmström, 1998)

LM implementation outcome

The impact that the adoption of the aforementioned LM methods had on the Process Industries detailed in the case studies examined is seen in Table 2's seventh column, which is perhaps the most significant factor for the purposes of this article. A good effect was seen in the majority of situations, most frequently shown as a decrease in waste (Muda), an increase in production, or an improvement in performance overall. It should be emphasised that the

outcomes in some instances were ambiguous, as in the case of the Ceramics case study done by [15] or the Food Process Industries reported in the work by [15]. As a result of a comparative case study, this is a very intriguing observation since it highlights how crucial ongoing and focused efforts from all parties are to the successful implementation of LM. Without a company's management or administration commitment to continually invest in its people and promote a culture of continuous improvement, different lean procedures, techniques, and technologies are insufficient to execute lean. It is acceptable to say that "Lean is a result of the tools and practises, not the other way around.

Hypotheses testing and validation

According to the first Hypopaper (H1), process companies that use only a few raw materials and produce vast quantities of a small number of products are more suited for using quality lean tools (such as Kaizen, TPM, 5S, etc.). With the exception of the food processing sector, which uses a wide range of goods but also employs TPM, most case studies that use a restricted variety of raw materials and really only create a few products in big amounts have applied TPM. H1 is further supported by the case study analysis of Facility A, which uses less than five raw materials and generates more than 10,000 tonnes of fewer than ten products annually, with the majority of the differences between the products' final packaging. TPM and Kaizen have been widely used in this plant.

According to the second Hypopaper (H2), process businesses that rely on specialised and rigid machinery and equipment cannot deploy production process lean tools (such as Batching, Production Levelling- Heijunka, etc.). The previous research shows that H2 holds true since all but two of the case studies analysed had rigid production processes because of the nature of the equipment used, which is specialised or process-specific, and do not use any kind of lean production tools. The findings of the Facility A case study, which while being characterised as an inflexible process using specialised equipment, show that H3 is false, also demonstrate the effectiveness of SMED and standardisation. The fourth Hypopaper (H4) claims that process industries where the product enters a discrete state early in the manufacturing process are more suitable for production process lean technologies (i.e., batching, JIT, etc.). As shown, H4 is invalid since only three case studies—all of which generated separate products at later stages of the manufacturing process—showed evidence of such lean procedures. The data gleaned from the investigation of Facility A's case study serves to further support the H5 hypopaper. According to the different responders,

productivity and profit rates have increased since the LM implementation started, while manufacturing costs and overall production costs have fallen. Also, they saw improvements in overall performance, which were shown by reductions in delivery times, an increase in production process flexibility, greater resource usage, and reductions in inventory, changeover times, defect rates, and waste from scrap and rework. It is important to note that the three exceptions identified in the literature-based case study analyses did not only not show positive results, but they also did not demonstrate negative effects from implementation. The problem in these cases was that the initial positive effects were not sustained, which raised doubts about lean practises and produced inconclusive results. The benefits LM could have on a facility cannot be long-lasting, as was already said, without consistent and persistent efforts from the workers and—most importantly—from the organization's supervisors. Also, as demonstrated by one of the questionnaire respondents' response, "Participation and on-going attention from stakeholders are two key components in the effective adoption of lean manufacturing (Figure 3).

LM practices adopted

Regardless of the kind of process industry subsector or product produced, TPM and 5S were the most often used LM methods. The adoption of TPM appears logical given that the majority of process industries use expensive, capital-intensive machinery that necessitates meticulous and methodical maintenance. Obviously, in the context of LM, the incorporation of TPM is essential to ensure that proper handling and default prevention are targets for all workers who are involved in the pertinent stages of the production process. Also, the use of 5S as a tool to improve output and raise quality at all stages of production seems to be a need given the multistage structure of the process sector. SMED, Visual Control, Standardization, JIT, Kanban, and VSM were additional techniques used by some of the facilities mentioned in the examined case studies. This observation is consistent with the findings of the pertinent theory. In contrast, Lean practises like stopping the line, cellular manufacturing, and focused factories either required extensive customization to be implemented in the production process or were inappropriate for the described process industries.

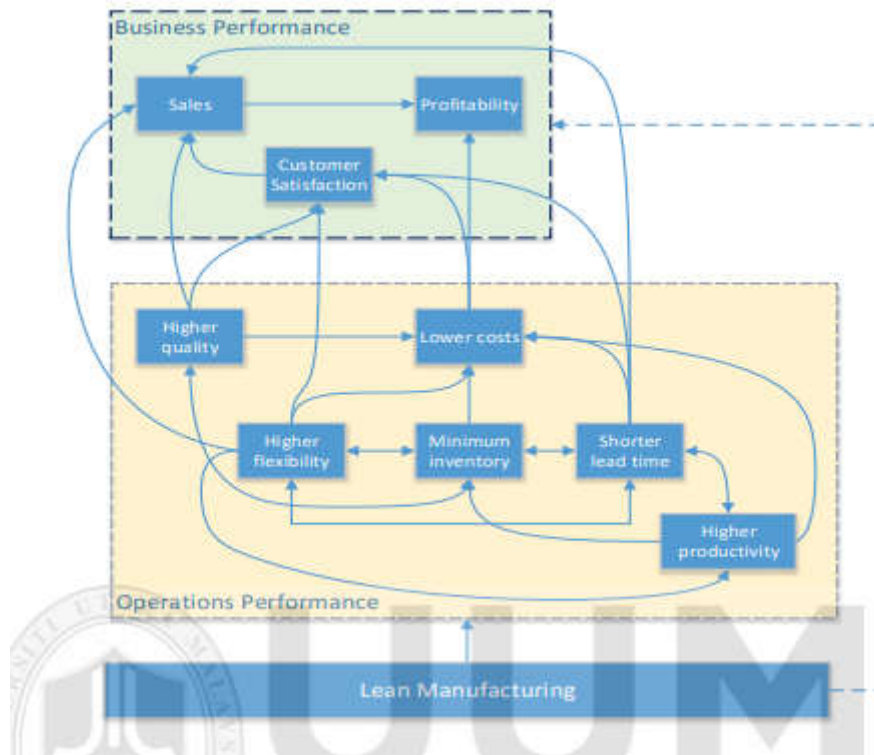


Figure 3. Framework of Relationship among Lean Manufacturing

Conclusion

The goal of this essay is to analyse and pinpoint the effects of lean manufacturing on the process industries. To determine the impact, published academic publications have been used throughout the current study. The literature-based arguments were further supported by a case study analysis using a questionnaire. An extensive, thorough explanation of the Lean paradigm was given, with a focus on a model for application in the process sector. The objective was to describe the value and obstacles of LM implementation in the process industries, as well as the issues and outcomes that result from this endeavour. In order to examine the implementation-related elements and the overall influence of LM on the process industries, many study hypotheses were developed as a result. The process for testing hypotheses was divided into two steps: both a case study analysis undertaken through organised, questionnaire-based interviews and an assessment of the relevant literature. The developed hypotheses are ultimately supported by the case study outcomes and a careful analysis of the case study observations. Although this industry dominates the world economies and every tiny change in the manufacturing process can have a significant impact on the actual economy and growth rates, further study on the economic consequences of a more extensive application of lean in the process industry might be done.

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