

# Comparative Study of Lean Manufacturing Tools Used in Manufacturing Firms and Service Sector

Vasudev Krishnan, C. Mallika Parveen

**Abstract**—Lean is an optimized manufacturing approach that aims to streamline the flow within an organization. Lean manufacturing caught the eye of the world due to Toyota's steady growth from a small company to one of the biggest automobile manufacturer in the world. After the success story that was TPS, many other car manufacturers started implementing tools used by Toyota into their systems. Today lean is not solely limited to the manufacturing industry, companies in the service sector are increasingly adopting and modifying lean strategies and practices to suit the needs of the service sector and thus streamlining their processes. The primary topic of interest in this paper is to study and compare the lean tools used in the manufacturing and service sectors and to come to a conclusion regarding trends in the lean tools adopted. A comparative study was undertaken between the lean tools in manufacturing firms and the service sector. Data obtained from 180 manufacturing firms and 108 healthcare facilities. The lean tools used were found to be TQM, JIT, kaizen, six sigma, SPC, TPM, kanban, job reengineering, work teams, benchmarking, organizational restructuring and business process reengineering.

**Index Terms**—healthcare industry, lean production, lean tools, manufacturing industry, service sector.

## I. INTRODUCTION

Lean manufacturing was a management philosophy parented by the Toyota Motor Company, the main principles and practices of lean manufacturing are based on and derived from the Toyota Production System (TPS). The term lean was not coined till the 1990s. Lean manufacturing is a philosophy that considers the expenditure of resources for any process that doesn't add value to the final customer as a non-value added process and hence is a waste that has to be eliminated from the system. Lean production, a term coined by Womack and Jones[1],[2] is no more a new term, almost every industry has been implementing lean practices in some form or the other in order to stay competitive and reduce manufacturing costs. Lean production encompasses a wide variety of practices or tools including just in time, total quality management, total productive management, kaizen etc. in an integrated system (Shah and Ward, 2003) [3]. Lean production is synonymous

with the Toyota Production System (TPS), the aim of lean production is to reduce the seven cardinal wastes: Defects, Overproduction, Transportation, Waiting, Inventory, Motion, Processing

Today, lean tools are not solely for use by the manufacturing industry, more organizations in the service sector such as healthcare and telecommunications etc. are adopting lean tools in order to streamline services and reduce time spent on non-value added activities. This article will be focusing on the healthcare industry as adequate data could not be obtained from the literature reviewed regarding lean adoption in any other service sector. Lean tools have been increasingly adopted by the healthcare industry in order to reduce costs, improve quality and the timely delivery of services. Table I provides a comprehensive description of all the lean tools found significant in this study.

Some of the major lean tools applied in the manufacturing industry were identified by Parveen and Rao [19] in their paper on lean supply chain, the fifteen tools identified by them were: hoshin planning, just in time (JIT)/pull systems, kaizen, kanban, poka-yoke, research and development (R&D), safety practices, six sigma, statistical process control (SPC), total productive maintenance (TPM), total quality management (TQM), Toyota production system (TPS), value stream mapping (VSM) and 5S. It is seen that lean manufacturing extends further than purely manufacturing and is at its best when implemented throughout the organization. Successful implementation of lean requires everyone in the organization to take an initiative and works best when there is a deep rooted culture of quality control such as in the automotive industry or the aerospace industry. Lean implementation in the service sector usually requires some process reengineering and job reengineering to take place.

Organizations generally implement one or more lean tools in order to reduce non value added processes. A Majority of the articles on lean production study a single aspect of lean and its performance in reducing waste such as McKone *et al.*, Hackman and Wageman [4],[5], a few studies have studied the influence of characteristics such as unionization, plant size and plant age on lean tool adoption such as Shah and Ward, Bhasin [3],[6].

The paper by Shah and Ward [3] offers great insight into the influence of unionization, plant age and plant size in the adoption of lean practices and methods. The paper shows that contrary to popular belief, the influence unionization has on the implementation of most lean practices is insignificant, but it has an effect on the ability to change work rules. Plant size is found to be a major influence on the implementation

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of the 22 evaluated lean practices and that larger plants are more likely to implement the evaluated tools. Plant age was found to have an influence on the implementation of a few of the lean practices evaluated.

This paper lists and compares the lean tools used by manufacturing industries and service sector using data gathered from articles ranging from 2002 – 2012, thus showing trends in adoption of various lean tools in both the industries. Further, we postulate reasons as to why each industry opts for different tools.

## II. LITERATURE REVIEW

An extensive literature review shows that the term “lean manufacturing” or “lean production” was first used by Womack *et al.* in their book *The Machine that Changed the World* [2]. Lean production was Toyota’s response to mass production. The next book of Womack and Jones, *Lean Thinking* (1996) [1] expanded on their research on lean manufacturing and studied its subsequent expansion into Europe and USA. Womack and Jones explain that lean thinking is more than just a technique, it is a deep rooted culture within the workplace that makes everyone in the organization continually improve operations.

The decade of 1990s saw the transformation of many manufacturing firms all over Europe and Asia into the lean approach. Manufacturing firms started adopting specific tools of lean to streamline certain processes within the manufacturing plant. For some actual applications of lean practices in manufacturing plants see Taj *et al.* [7], Akbulut-Bailey *et al.* [8].

In the 2000’s lean production in some form was being implemented into almost every manufacturing industry, processes like JIT and TQM were being widely implemented by many manufacturing plants. There have been quite a few articles published studying the influence that certain factors such as plant size, unionization and plant age have on lean tool adoption, the most notable and detailed of these is Shah and Ward [3], where the influence of all 3 factors is studied in detail. There have also been other articles studying the influence of one of these factors on lean adoption and the performance such as Bhasin [6], Martinez-Jurado *et al.* [9]. There have also been multiple articles assessing performance after lean adoption within manufacturing industries such as Taj [10] and Ghosh [11].

Recently lean tools have been increasingly adopted by service sectors to streamline their services and reduce costs. The most common service sectors that have adopted lean tools are telecommunications and healthcare. Psychogios [12] has investigated the implementation of lean techniques in a telecommunications industry whereas there are multiple articles related to the adoption of lean in healthcare industry such as Brandao de Souza [13], Chadha *et al.* [14] and Chiarini [15].

The data in this article is collected from various sources that have studied the performance and implementation of lean tools in the manufacturing and services industries. Data for the manufacturing plants is taken from Taj [10], Ghosh [11], Jeyaraman *et al.* [16] and Salleh *et al.* [17]. As data for telecommunications companies was not readily available only the healthcare sector is taken into consideration, with

data being gathered from a comprehensive study conducted by Yasin, Zimmerer *et al.* [18].

## III. ANALYSIS

### A. Data Collection

The data used in this investigation was gathered from articles published between 2002 and 2012, therefore giving a view of the implementation of lean tools in the past 10 years. This data was then put in the forms of graphs in order to show the extent of variations and study any patterns that would arise. The data was reviewed for implementation of lean tools.

The data obtained for the manufacturing industry was chosen so that most of the major manufacturing sectors was well represented so that the data gave an accurate overview of the tools adopted by manufacturing firms.

The data used to study the service sector was collected from a paper studying contemporary managerial philosophies within the healthcare sector by Zimmerer *et al.* [18]; these contemporary managerial philosophies were seen to be representative of the lean principles and philosophies.

### B. Manufacturing Industries

From the reviewed articles, i.e. Taj [10], Ghosh [11], Jeyaraman *et al.* [16] and Salleh *et al.* [17], a total of 180 manufacturing firms were taken as the sample for this study. Out of this sample of 180 companies, 65 companies were from China, 79 companies were from India and 36 companies were from Malaysia. In order to show the variation in the types of manufacturing plants considered, the companies were classified into six types based on the similarity of their products. Figure 1 shows the classification of manufacturers based on the similarity of their products

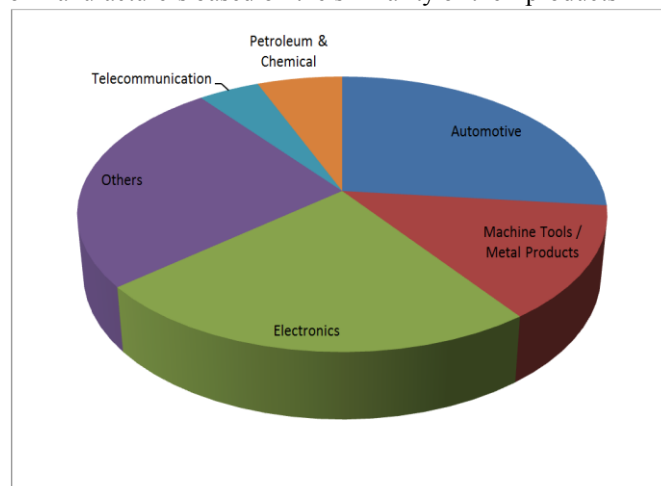


Fig. 1 Classification of manufacturing firms based on similarity of products

It can be seen from the figure that all types of manufacturing industries are being represented adequately in the study; it is also worthwhile to note that although telecommunication has been mentioned as a service sector earlier, in this case it refers to a telecommunications equipment manufacturer. In order to maintain clarity and to properly convey the differences in the industries, only a few lean tools for which adequate data could be obtained were

compared and studied. Figure 2 shows the lean tools implemented by these 180 manufacturing industries.

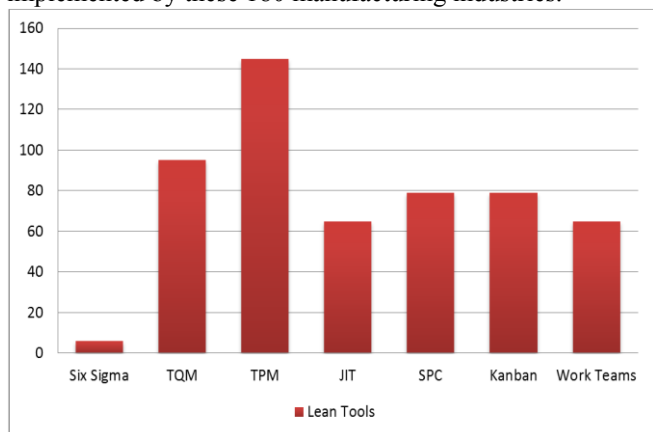


Fig. 2 Lean tools adopted by manufacturing firms

In order to provide a better representation of these figures, figure 3 expressed the percentage of companies that implement each lean tool.

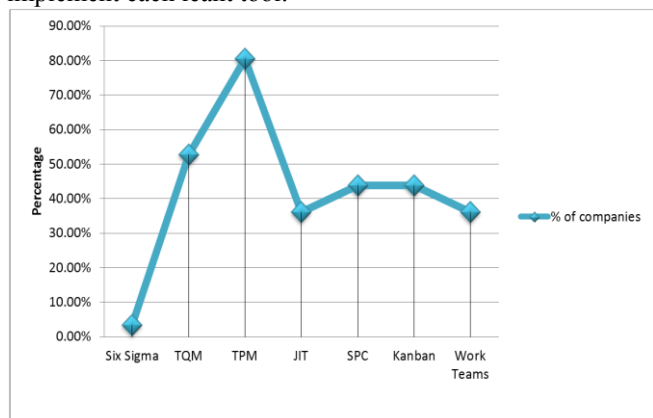


Fig. 3 Percentage adoption of lean tools in manufacturing firms

It can be noted from the figure that the most commonly adopted tool in the manufacturing firms studied is TPM, which is adopted by a total of 80% of the companies studied. Even TQM shows reasonably high levels of adoption with a total of 53.3% of the companies studied adopting it. Six Sigma processes is seen to have the least adoption with only 3.3% of the companies studied opting to adopt it.

The above obtained data was also compared to the results obtained in a paper by Parveen and Rao [19] on lean supply chain.

### C. Service sector

Service sectors that most commonly adopt lean practices are the healthcare and telecommunications sectors, as not enough data could be found regarding telecommunication companies that have adopted lean tools in the literature review done, healthcare institutions were used to gauge the implementation of lean tools in the service sector. The data was collected from a paper by Yasin, Zimmerer *et al.* [19] studying the adoption of contemporary managerial philosophies in a hospital operational setting, these managerial philosophies correspond to tools used in the lean industry such as JIT, TQM etc. The sample size of the healthcare facilities studied was 108. Figure 3 illustrates the lean tools used in the healthcare facilities studied.

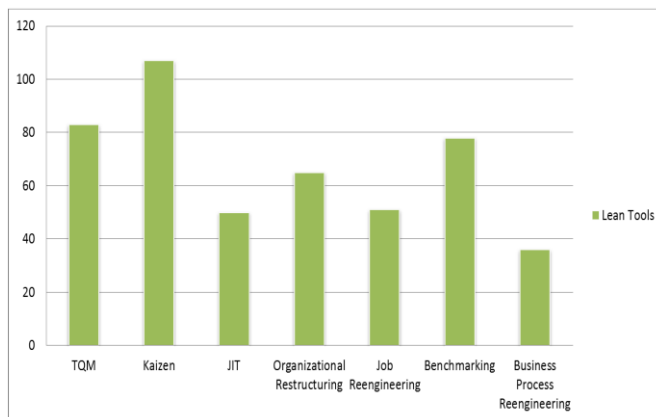


Fig. 4 Lean tools adopted by healthcare facilities

In order to get a better understanding of the amount of implementation of the lean tools within the healthcare sector, above data was plotted as percentage values. Figure 5 shows the percentage adoption of lean tools in the healthcare sector.

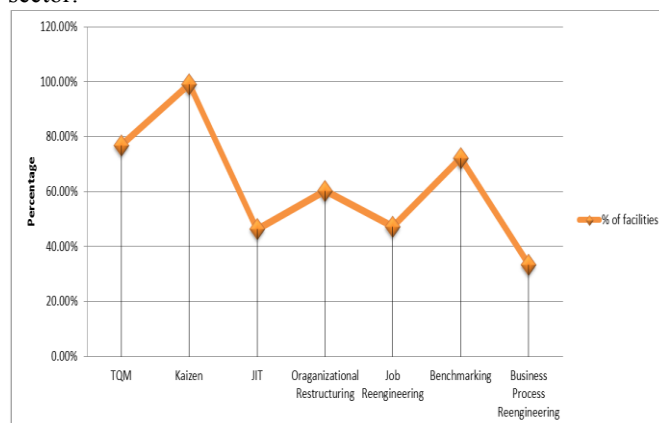


Fig. 5 Percentage adoption of lean tools in healthcare sector

From the figure it is seen that the most implemented lean tool in healthcare facilities is kaizen, with all but one institute employing kaizen or continuous improvement practices into the running of the organization. The second highest adopted tool is seen to be TQM, which is being implemented in 76.85% of the surveyed hospitals. It is interesting to note that the healthcare industries gravitate more towards reengineering and restructuring approaches. It can be noted that although there is evidence of six sigma tools being used in the healthcare industry as noted by Chiarini (2012), there is not enough data present in reviewed literature regarding its implementation.

## IV. RESULTS AND DISCUSSION

Comparing the results of Figure 2 with those of Figure 3, a significant difference is seen in the tools adopted by the two industries. Although it is interesting to note that JIT and TQM have high to medium levels of implementation in both the industries, with TQM being implemented by 76.85% of the hospitals investigated and 53.33% of the manufacturing firms, we see a deep rooted philosophy of high quality being present in both the industries. JIT practices have been implemented by 46.29% of the hospitals investigated and 36.11% of the manufacturing industries, although this is of a lower degree of implementation, they are implemented to

almost similar levels in both the industries, the manufacturing industry benefits from JIT due to its ability to reduce in process inventory and the related carrying costs. The healthcare industry can also benefit from having the right product in the right quantity at the right time, with a lot of healthcare products coming with expiry dates, this can help in reducing spoilage and waste and also helps in reducing storage costs.

In the manufacturing industry, it is noted that 80% of the companies investigated have implemented TPM practices, this is in line with what was expected due to manufacturing industries relying on machines and other equipment that need constant maintenance in order to run effectively and efficiently. It is interesting that TPM is not referenced more widely in healthcare industry as even hospitals rely on high tech equipment. Some lean tools found exclusive to the manufacturing industry are SPC, kanban or the pull system and work teams. Both kanban and SPC could help the healthcare industry as kanban systems can be used as a means through which JIT can be achieved, automatic replenishment systems could help in the pharmacy etc. whereas SPC could be used by healthcare institutes in order to identify bottlenecks, wait times and other sources of delay within the processes. Work teams do not seem to have any major advantage of being implemented in the healthcare industry.

Within the service sector or in particular the healthcare industry, it is seen that kaizen or continuous improvement is implemented by a vast majority of hospitals, with 99.07% implementing the practice. Kaizen is being increasingly implemented by hospitals in order to reduce wasteful activities that have built up over time in the system and therefore freeing up the staff to do real value added work. It is also noted that benchmarking is also implemented by a large number of hospitals, with 72.2% of the hospitals investigated using it. It is interesting to note that organizational restructuring and job reengineering are being used by the hospital industry much more than manufacturing industries have been using it.

The data was also compared to the the lean tools identified in the paper by Parveen and Rao [19]. The lean tools identified in the paper were: kaizen with 65.4% usage, 5S with 40.4% usage, JIT with 32.0% usage, VSM with 31.1% usage, kanban with 28.9% usage, six sigma with 24.6% usage, TPS with 16.7% usage, TQM with 16.2% usage, TPM with 12.7% usage, pokayoke with 12.7% usage and finally R&D, safety practices, SPC and hoshin planning with 10.5%, 8.3%, 7.9% and 7.5% usage respectively.

The consolidated list of lean tools from both the manufacturing industry and the service sector can be seen in Figure 6.

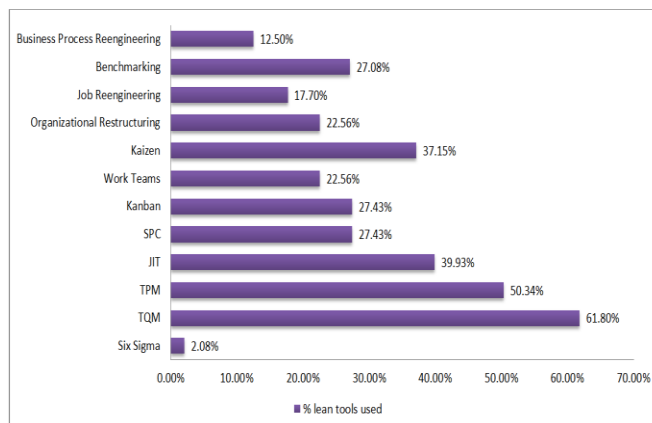


Fig. 6 Consolidated list of lean tools obtained in the paper

On comparing the above table to the results obtained by Parveen and Rao [19], it can be seen that there is a significant difference in the values obtained for the usage of TPM and TQM, there is found to be a significant increase in the use of TPM and TQM. It is also seen that there is a significant reduction in the number of organizations using kaizen. The usage of kanban and JIT are found to be very similar in both the studies. The presence of reengineering and restructuring practices in this paper is due to their importance in the service sector, which has not been studied in the paper by Parveen *et al.* [19]. The difference in the percentage use of six sigma tools can be due to the different sample sizes used in papers. The data found regarding six sigma implementation was scarce and not easily accessible.

Figure 7 shows a chart having the integrated tools used in manufacturing firms and service sector.

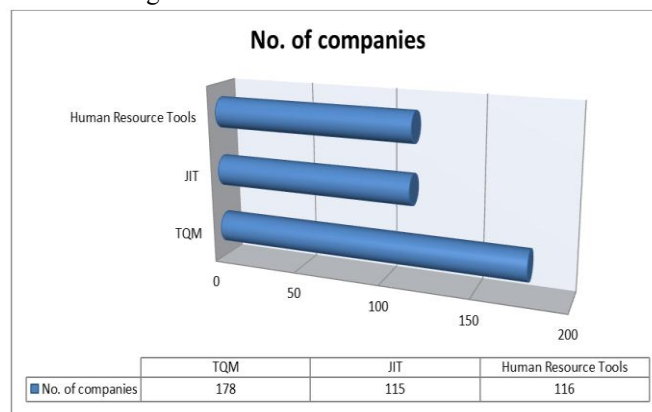


Fig. 7 Integrated list of common tools

It can be seen from figure 7 that TQM is seen to be the most commonly used tool when considering both manufacturing firms and service sector, this can be explained by the high levels of quality that both the sectors strive towards. Human resource tools include work teams and job reengineering; these tools have been bundled together due to them being highly interdependent on the other. Human resource tools are seen to have a much larger influence on the service sector due to the high importance given to customer satisfaction and customer service in these industries. Human resource is a very important aspect of lean production that is often overlooked by manufacturing firms, with them focusing more on multifunctional work teams etc. JIT and human resource tools are seen to have

equal adoption in both industries studied. JIT tools are important in the healthcare sector due to the presence of expiry dates for medicines etc. JIT therefore helps in assuring that the right product is available in the right quantity at the right time ensuring seamless service. Even though there is evidence regarding six sigma implementation in the service sector, sufficient data could not be collected to reach a conclusion regarding the degree of implementation.

## V. CONCLUSION

The lean tools adopted by the manufacturing industry were compared to some of the lean tools adopted by the service sector or healthcare industry in particular and conclusions were made about why certain tools are more relevant to a certain industry. An integrated list of lean tools used in both the manufacturing firms and service sector was compiled and it was seen that TQM, JIT and human resource tools were the most used tools common to both sets of industries. Human Resource tools were seen to have a higher importance in the service sector as compared to the manufacturing sector. JIT tools were found to be equally popular in both the industries. During the literature review for this article it was found that there was a lack of data on the implementation of six sigma tools in the service sector, this could be an area of further research.

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