

Study of Tools, Techniques and Factors used in Lean Six Sigma

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Abstract—Many companies look for ways to improve their production and management processes in order to remain competitive in the market. This calls for ways to reduce production cost, enhance productivity and improve product quality. Therefore, companies must utilize the available resources efficiently in order to cater their customers with high quality products at low prices.

Lean Manufacturing focuses on elimination of waste and thus increases overall speed of the processes or services; its use increased after the 1973's energy crisis in Japan. While, in 1980s appeared six sigma in USA, which focuses on quality and thus reduce variation in process and improve the efficiency of process. Recently, Lean six sigma is a business improvement methodology, which combines tools and techniques from both lean manufacturing and six sigma, the result, is better quality, optimized process and increase efficiency.

This study shows that the developing countries and the most advanced are given more importance to lean six sigma than other least developed countries. The most factors that used in lean six sigma are time, cost and defects, but some of research merged among more than a factor from these factors.

The tools and techniques most used for lean Six Sigma in the industry sector are the value stream mapping, cause and effect diagram and process flow diagram. The tools and techniques most used in the health sector is the cause and effect diagram technique, while the value stream mapping, process flow diagram and cause and effect diagram are the tools and techniques most used in the service sector.

Index Terms— Lean manufacturing, Six sigma, Lean six sigma, Tools, Techniques, Factors focuses, Sectors focuses.

1 INTRODUCTION

When Japan started to build automobiles for the Japanese market after World War II, they had to modify Ford's approach for Toyota's manufacturing system. Lack of resources forced Toyota's executives, Ohno and Shingo developed a manufacturing system that would use few resources; the system was later named lean manufacturing[1].

Lean Enterprise originated from the Toyota Motor Corporation as the Toyota Production System, and increased in popularity after the 1973 energy crisis. The concept of Six Sigma was developed in the early 1980's at Motorola Corporation. General Electric Corporation popularized six Sigma in the late 1990's. Lean Six Sigma is an approach focused on improving quality, reducing variation and eliminating waste in an organization.

The concept of combining the principles and tools of Lean Enterprise and Six Sigma has occurred in the literature over the last several years. The majority of Lean Six Sigma applications have been in service private industry, focusing mostly on manufacturing applications [2-3].

1.1. Lean manufacturing:

Lean manufacturing is a manufacturing philosophy, which focuses on delivering high quality products at the lowest price and at the right time. Lean manufacturing focuses on eliminating waste or non-value added activities, leans basic value proposition is that principles for improving workflow, decreasing setup time, eliminating waste, and conducting preventive maintenance will speed up business processes and return quick financial gains [4-6]. Table (1) below shows the types of wastes of Toyota production system.

TABLE 1

TYPES OF WASTES OF THE TOYOTA PRODUCTION SYSTEM [1]

No	waste	Type of waste	Nature of Waste
1	People	Processing	Variation between operators' methods Variation between standard and actual operation Processes that are not statistically capable
2		Motion	Components and controls outside easy reach Layout not standardized causing double handling Widely spaced equipment and operators bending
3		Waiting	Operators waiting Operators slower than line Operators watching equipment and operation
4	Quantity	Inventory	Prescribed storage volume exceeded Deteriorating material with old dates Sophisticated stores system
5		Making too much	Smooth flow of goods and piles of work in progress Target and achievement is unclear Excessive lead-time and storage times
6		Moving things	Stacking and un-stacking of components Conveyors and Widely spaced equipment Many busy forklifts
7	Quality	Defects	Poor material yield Large rework area and work in scrap bin Difficult assembly with high inspection levels Irregularity of work with high customer complaints

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1.1.2. Tools and techniques in relation to Lean manufacturing:

The most important tools and techniques used in a Lean manufacturing approach are[7-8]:

- Value stream mapping (VSM).
- Cellular manufacturing.
- Just in Time (JIT)
- Total Productive Maintenance (TPM)
- Single Minute Exchange of Dies (SMED)
- Leveling (total production)
- Kanban
- Kaizen
- Workplace Organization (Sort, Set order, Shine, Standardize and Sustain) (5S)
- Standardization

1.2. Six sigma:

Six Sigma is “a program aimed at the near-elimination of defects for every product, process and transaction.” Six sigma could also be described as an improvement program for reducing variation, which focuses on continuous and breakthrough improvements. Improvement projects are driven in a wide range of areas and a different level of complexity, in order to reduce variation. The main purpose of reducing variation on a production or service is to satisfy customers. The goal of six sigma is that only 3.4 million customers should be unsatisfied. Six sigma has two methods[9-10]:

1.2.1. Continuous improvement (DMAIC) methods:

The methodology used to improve an existing process in six sigma is the DMAIC process, which is divided into five stages:

- Define: the purpose of this phase is to clarify the goals and value of a project.
- Measure: the purpose of this phase is to gather data on the problem.
- Analyze: the purpose of this phase is to examine the data and process maps to characterize the nature and extent of the defect.
- Improve: the purpose of this phase is to eliminate defects in both quality and process velocity.
- Control: the purpose of this phase is to lock in the benefits achieved by doing the previous phases. [2], [11- 12]

1.2.2. Reengineering (DMADV) methods:

The methodology used to improve system for new process or products in six sigma is the DMADV process, which is divided into five stages:

- Define: the purpose of this phase is to clarify the goals and value of a project.
- Measure: the purpose of this phase is to gather data on the problem.
- Analyze: the purpose of this phase is to examine the data and process maps to characterize the nature and extent of the defect.
- Design: the purpose of this phase is to redesign/ design (detailed) the process to meet the customer needs.

- Verify: the purpose of this phase is to verify the design performance and ability to meet customer needs. [12-13]

The table (2) below illustrates comparison between Continuous improvement (DMAIC) method and Reengineering (DMADV) method

TABLE 2
COMPARISON BETWEEN DMAIC AND DMADV [14]

DMAIC	DMADV
Start from once problem	Start from practical solution (found)
Improvement system for existing processes falling	Improvement system for new process or products
Organization focused	Customer focused
A separate task	Part of the tasks
Small team	Big team
Schedule medium	Schedule high
Incremental improvement	Start from high levels quality
Projects to improve (many)	Projects to improve (little)
Small effect	Big effect
Continuous improvement	Reengineering

1-2-3-Tools and techniques in relation to Six Sigma:

The most important tools and techniques used in a Six Sigma approach are[15-16]:

- Process mapping/flow charting.
- Pareto diagram.
- Cause and effect analysis.
- Process capability analysis.
- Analysis of variance.
- Statistical process control.
- Regression analysis
- Control charts.
- Robust design
- Belt system (MB, GB, BB, YB)

Figure 1. Illustrates the tools and techniques used in lean manufacturing, six sigma and the common tools and techniques between them.

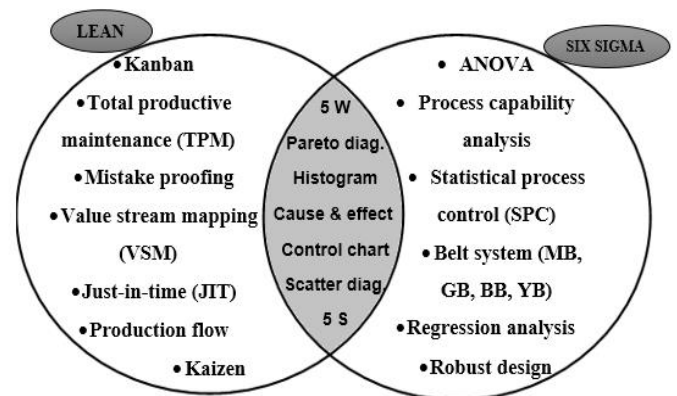


Fig. 1. Tools and techniques of lean and six sigma[17]

1.3. Lean Six Sigma:

Lean Six Sigma is an approach focused on improving quality, reducing variation and eliminating waste in an organization. It is based on the concepts of combining two improvement programs, Six Sigma and Lean manufacturing, also known as Lean Enterprise. Six Sigma is both a quality management philosophy and a methodology that focuses on reducing variation, measuring defects and improving the quality of products, processes, and services [18], [2],[12].

The study aims to: (1) clarify the concept of lean, six sigma and lean six sigma in practice and how to execute and perceive lean six sigma. (2) Identify success parameters for lean six sigma implementation and factor focus and sectors that have focused.

2. METHODOLOGY:

This study was adopted to researches published about lean six sigma. The literature search is limited to the English language only and available from 2008 to October 2013 (lean Manufacturing [6,7,19–53], Six Sigma[15,54–78], Lean Six Sigma[1,3,9–12,16,18,79–101].

The criteria of selection of the papers includes the publication years, either applied as a case study or described as theory and the field of implementation. The search results were sort out as case study or theories, classify by sectors, factor focused, tools and techniques used and have been focused to important sectors industry, service and health. The data collected are analyzed and the results are present in graphs.

3. RESULTS:

From lean six sigma relevant found research publications there are 82 (89%) papers are case study based while 10 (11%) papers are theory based.

Figure 2. shows the distribution total search of study materials for the year from 2008 to October 2013. It illustrates the incremental to 2012.

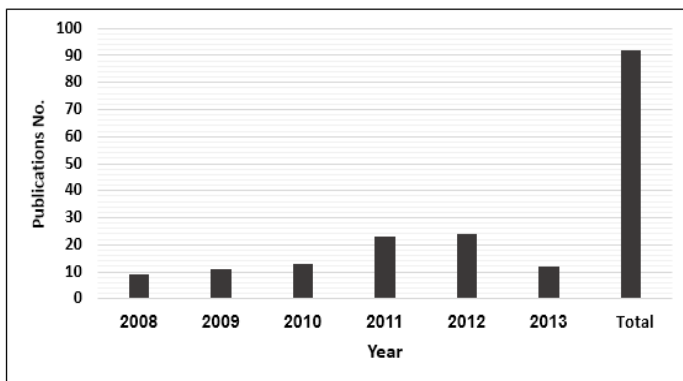


Fig. 2: Lean six sigma in this study since from 2008 to 2013

developed and developing countries that the United States is the leader, followed by India and then shows the least with the advent, Note three Arab countries, though there are few researches Iraq, Egypt and Jordan.

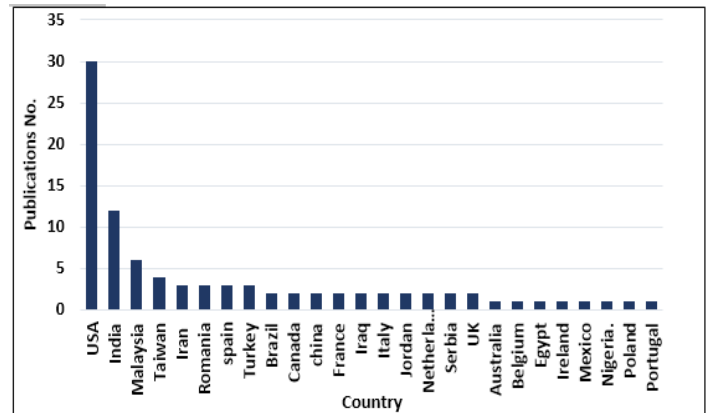


Fig.3: Countries that have used Lean Six Sigma since from 2008 to 2013

Figure 4 illustrates the cumulative sectors, which used in Lean Six Sigma, according to year. From this figure, it can be shown that the industry sector is the most used the lean six sigma, follow general sector, health and service but the less cumulative used IT, environmental and finance sectors.

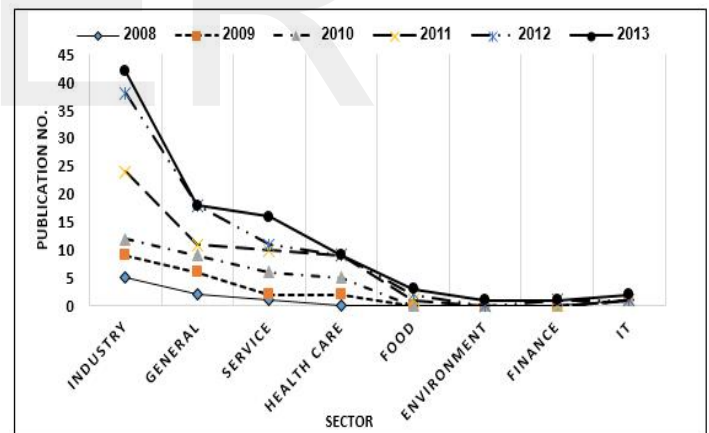


Fig. 4: The cumulative sectors used in Lean Six Sigma, according to Year

Figure 5 shows the lean six sigma implemented in the industry sector where the defects are less tolerable. Followed by general sector includes printing, military, education, government, decision making and recycle materials. Followed by service sector includes mainly banks, investment, call centers, telecommunication and computer technology. Followed by health care sector where the defects not allowed, health sector includes pharmaceutical, clinical and drugs.

Figure 3. Shows lean six sigma research distributed to various

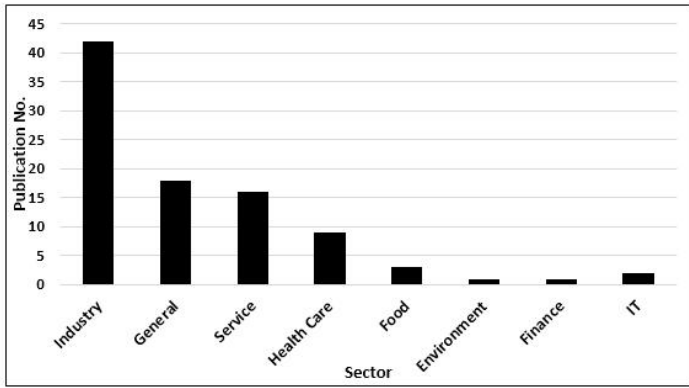


Fig. 5: Sectors that have used Lean Six Sigma from 2008 to 2013

Figure 6. shows the factor that used in lean six sigma, from this figure, it is clear that the highest factor studied is the time and later came factor cost and defects came third, but some of research merged among more than a factor time - cost or time- defects.

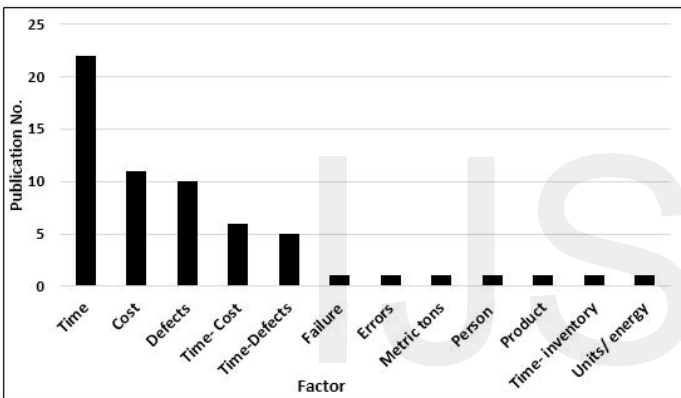


Fig. 6: Factors that used in lean six sigma

Figure 7. shows the tools and techniques most widely used in lean six sigma, from this figure, it is clear that process flow diagram, cause and effect or fishbone diagram and value stream mapping the most commonly used, but VSM is used widely in Lean manufacturing, while pareto chart, hypothesis testing and failure mode effects analysis (FMEA) came the last

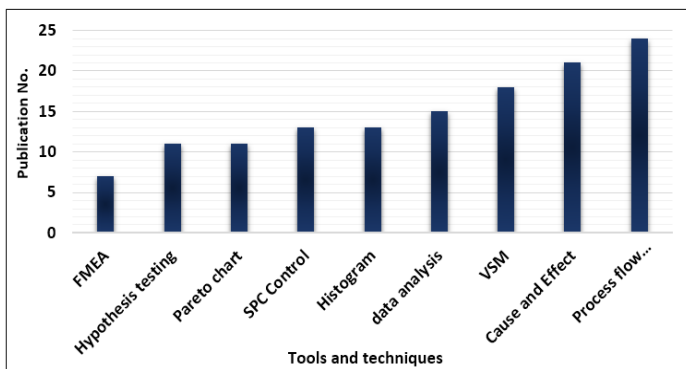


Fig. 7: Tools and techniques most widely used in Lean Six Sigma

Figure 8. Shows the cumulative tools and techniques of Lean Six Sigma, according to year; from this figure, it is clear that the tools and techniques was use most in year 2011.

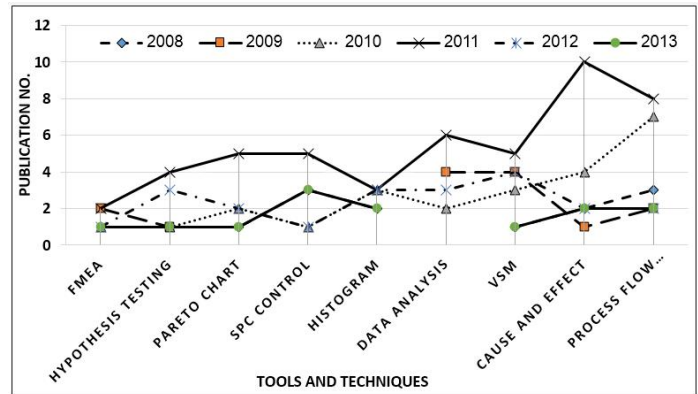


Fig. 8: The cumulative tools and techniques of Lean Six Sigma, according to year

Figure 9. shows the tools and techniques most commonly used in lean Six Sigma in the industry sector, from this figure, it is clear that the value stream mapping (VSM), cause and effect diagram and process flow diagram are the most commonly used to implementation lean six sigma in industry sector.

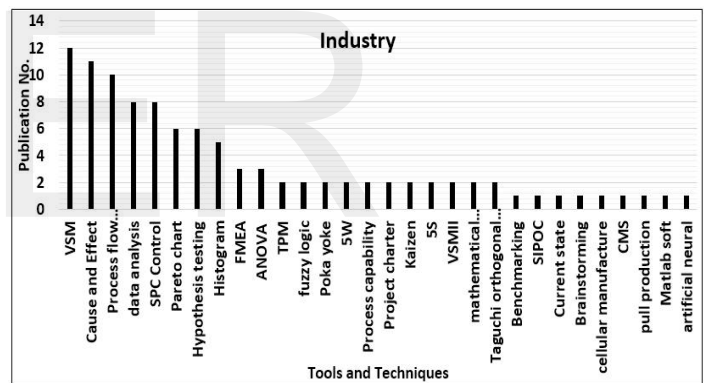


Fig. 9: Tools and techniques most widely used in Lean Six Sigma in industry sector

Figure10. Shows the tools and techniques most commonly used in lean Six Sigma in the health sector; from this figure, it is clear that the cause and effect diagram was the most widely technique used in this sector, but value stream mapping technique was the least technique used in this sector.

Figure 11. Shows the tools and techniques most commonly used in lean Six Sigma in the service sector, from this figure, it is clear that the value stream map, process flow diagram, cause and effect diagram are the most tools and techniques used in the service sector.

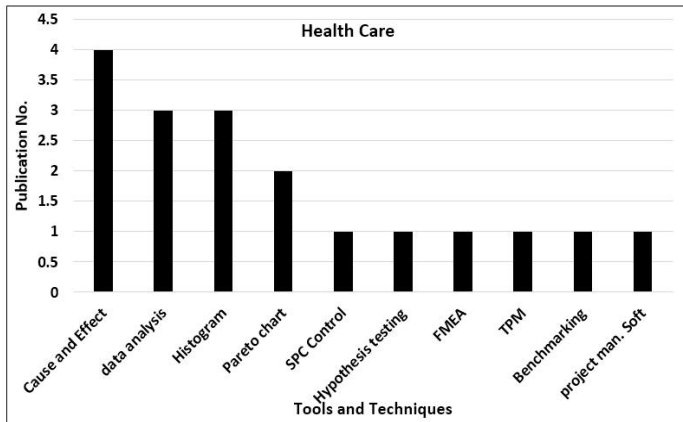


Fig. 10: Tools and techniques most widely used in Lean Six Sigma in health sector

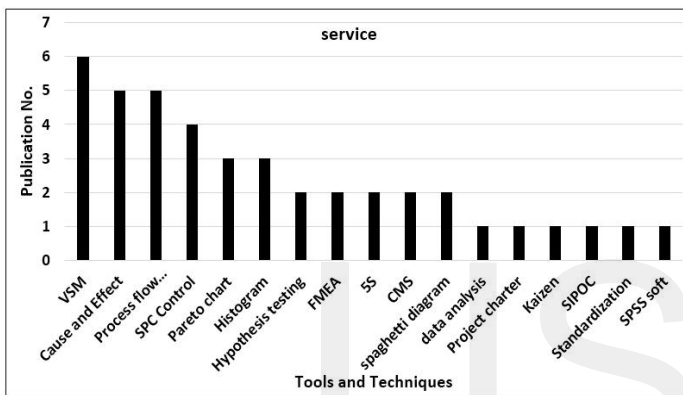


Fig. 11: Tools and techniques most widely used in Lean Six Sigma in service sector

4. CONCLUSIONS:

This study is a try to survey previous studies of lean six sigma, after analyzing the data of previous studies and classified according to the criteria specified, the important results from this study are:

- 1- Lean Six Sigma useful and used most sectors such as industry, public services and health care.
- 2- Lean Six Sigma can be applied to large and small organizations.
- 3- The developing countries and the most advanced give more importance to implementation of lean six sigma than other least developed countries.
- 4- The factors that most used in lean six sigma are time, cost and defects, but some of researchs merged among more than a factor.
- 5- The tools and techniques most widely used in lean six sigma are the process flow diagram, cause and effect or fish-bone diagram and value stream mapping.
- 6- The tools and techniques most used for lean six sigma in the industry sector are the value stream mapping, cause and effect diagram and process flow diagram.
- 7- The tools and techniques most used in the health sector is the cause and effect diagram technique, while the value stream mapping, process flow diagram and cause and ef-

fect diagram are the tools and techniques most used in the service sector.

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