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To cite this article: Aulia Ishak *et al* 2020 *IOP Conf. Ser.: Mater. Sci. Eng.* **1003** 012096

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# A systematic literature review of lean six sigma

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**Abstract,** Competition in the industrial world lately is very tight. This intense competition requires companies to be able to compete very well. Companies must be able to provide good quality products that they produce. With the increasing competition, the supply of quality products has become a competitive advantage. Therefore, companies need to adopt competitive strategies that can improve the quality of their products, one of which is quality control. One of the quality control methods that can be used is Lean Six Sigma. Lean Six Sigma is a combination of two methods of improvement. Lean is a philosophy to reduce or eliminate unnecessary time, materials, and activities, while Six Sigma is a concept designed to increase overall effectiveness by defining, measuring, analyzing, improving, and controlling processes. Both the Lean's philosophy and Six Sigma methodology focus on increasing bottom yields, increasing customer satisfaction, reducing defects and improving organizational performance. Therefore, this study has tried to review the current status of Lean Six Sigma from published research articles to reflect the purpose of this paper to compile the latest scenario for the deployment of Lean Six Sigma in various industries literature on Lean, Six Sigma and LSS (Lean Six Sigma).

## 1. Introduction

Lean Six Sigma approach is chosen and used to eliminate waste, improve quality, reduce variation or defects in an organization. Therefore, Lean Six Sigma (LSS) has become a popular tool to increase excellence in manufacturing [1]. Lean focuses on eliminating non-value added activities and waste in the industry and also focuses on reducing total cycle times. Support of various tools and techniques for improvement such as Kanban system, 5S, Cause and Effect Analysis, Value Flow Mapping (VSM) and many others [2]. Six Sigma is a business improvement strategy that is applied to eliminate and identify the causes of defects or errors in business processes by concentrating on activities that are relevant to the client. Six Sigma implementation has a key component of success related to commitment to supporting infrastructure, top management, training and statistical tools [3].

Various jobs and / or models to solve various problems by implementing Lean, Six Sigma and LSS have been projected by many researchers around the world. An integrated lean sigma approved implementation that delivers impressive improvements in key metrics and huge financial savings will be generated by the organization [4]. Therefore, integrating these two approaches will make the organization more effective and efficient and also help achieve good performance faster than each approach applied separately [5]. On the off chance that the consequences of QC tests can't satisfy the acknowledgment models, the aftereffects of examination of the entire arrangement of the estimations



on that day must be eliminated or should be re-dissected, and an incomplete or full re-approval of the strategy considered [24].

Therefore, this study tries to publish the current status of LSS from 15 research articles published in 2010 to 2018 that reflect the purpose of this paper to develop current scenarios using LSS in various industries. Perhaps this studio can help companies understand LSS in determining high project success rates.

## 2. Research Method

This work is an exploratory studio because it is a review of what has been discussed in the literature on Lean Six Sigma. The author uses systematic literature to achieve the overall objectives of this study. It is also characterized as a theoretical-conceptual study using literary techniques. The use of library conclusions is relevant because it is a systematic and reproducible solution to the understanding, approval and review of existing documents relative to the theme under study.

### 2.1. Inclusion criteria

A systematic literature review was obtained from academic journals in the field of lean six sigma released by leading databases such as Research Gates, Emerald Insight, Elsevier, Taylor and Francis and Inderscience. The main criterion used is the paper translated by the research into quality control in the field using the lean six sigma method in various industries. Discuss English is the language medium used, there are two parts to the selection process, namely the initial selection of search results, based on reading the paper abstract, then the final selection of the list of papers that were initially selected by reading the entire content. The contents of this paper will be studied and classified based on the research methodology, type of industry, author profile, research country and year of publication.

### 2.2 Data collection

Below are some journals taken to explain the benefits of applying the Lean Six Sigma method taken from leading databases such as Emerald Insight, Research Gates, Elsevier, Francis and Inderscience and Taylor. Including a paper discussing research in the field of quality control with Lean Six Sigma methods in various industries is the main criterion used. Information about Lean Six Sigma in various industries can be seen in Table 1.

**Table 1.** Information of lean six sigma

No	Journal Name	Acronym	Country of origin
1	International Journal of Lean Six Sigma	IJLSS	India
2	International Journal of Lean Six Sigma	IJLSS	Canada
3	International Journal of Lean Six Sigma	IJLSS	Brazil
4	Business Process Management Journal	BPMJ	UK
5	International Journal of Production Research	IJPR	Brazil
6	International Journal of Lean Six Sigma	IJLSS	USA
7	Total Quality Management and Business Excellence	TQMBE	UK
8	International Conference on Industrial Engineering and Engineering Management	IEMM	Singapore
9	International Journal of Lean Six Sigma	IJLSS	USA
10	Quality Management Journal	QMJ	USA
11	International Journal of Management Science and Engineering Management	IJSEM	Portugal
12	American Journal of Industrial Engineering	AJIE	USA
13	International Journal of Lean Six Sigma	IJLSS	Brazil

14	International Foundation for Production Research	IFPR	Taiwan
15	European Journal of Industrial Engineering	EJIE	USA
16	International Journal Business Excellence	IJBE	India
17	Quality Innovation Prosperity	QIP	Portugal
18	International Journal of Lean Six Sigma	IJLSS	Malaysia
19	Production Planning & Control	PPC	Taiwan
20	Journal of Manufacturing Technology Management,	JMTM	UK
21	Production Planning & Control	PPC	India
22	<i>International Journal of Six Sigma and Competitive Advantage</i>	IJSSCA	Tiongkok

### 3. Result

#### 3.1. Time Distribution of Lean Six Sigma Journals

Lean Six Sigma was first integrated in the US in the George Group in 1986 [6]. This technique became more popular after 2003. In 2008 there was a rapid increase in the number of publications published by Lean Six Sigma that were approved by the scientific community in Brazil. The results of this study indicate that this study reinforces other literature studies. In 2007 the development of Lean Six Sigma did not experience a significant increase in publication support [7]. In 2005 the number of Lean Six Sigma publications in academic journals experienced a significant increase. In 2012 there were 47 articles up to 2013. There were 149 articles about Lean Six Sigma published in the last five years. This proves that there is an increasing interest in publishing Lean Six Sigma methods rapidly.

#### 3.2. Lean Six Sigma Tools

The following 6 tools are most often used in implementing Lean Six Sigma, namely control charts, making Value Stream Mapping, DMAIC (Define, Measure, Analyze, Enhance, Control), Kaizen, Histogram and Ishikawa Diagram. The reason for the increasing use of Six Sigma is because of its simple application because there is no statistical equation. Thomas et al said that the use of Six Sigma is avoided by companies because of the complex tools and techniques that cause employees and managers to feel intimidated. Value Stream Mapping, Cause and Effect Analysis, 5S, DOE and Pareto charts are tools and techniques used in the DMAIC method, because the strong reason for implementing Lean Six Sigma is DMAIC. The reason for using this tool in most cases is that it is simple because it does not use statistical equations [8]

#### 3.3. Lean Six Sigma in Various Industries

Matthew Franchetti, Pukhraj Barnala discusses the application of Lean Six Sigma for the recycling industry. This research uses the Six sigma DMAIC methodology. It aims to harmonize and optimize processes and eliminate defects and errors. With the implementation of Lean Six Sigma, the results are obtained in the form of a reduction in non-value added activity, an increase in productivity of 7.3 percent for paper bales, 12.8 percent for mixed bales and 1.6 percent for old corrugated container bales (OCC). This resulted in the project generating annual savings in excess of \$ 65,000 on the facility [9].

Alexandros G. Psychogis discusses the use of Lean Six Sigma for an airline. the aim of this article is to investigate these critical factors. There are certain factors that influence with implementing Lean Six Sigma such as quality driven organizational culture, customer satisfaction, leadership and technical systems. Applying the use of Lean Six Sigma, it focuses on managers' responses, explores the interrelationship of both negative and positive factors and provides future research with an integrated framework in different organizations. [10].

Xianfei Jin, a study that describes a simulation by implementing the Lean Six Sigma Approach for improvement in an outpatient eye clinic in Singapore. Lean Six Sigma concepts are used in research

and implemented into the healthcare industry by using Six Sigma DMAIC (Define, Measure, Analyze, Improve, Control) to identify opportunities for improvement. The redesigned assignment system was able to reduce average patient waiting time by 23.7% by implementing Lean Six Sigma [11].

Nicholas Roth, Matthew Franchetti, discusses the use of Lean Six Sigma which aims to improve the printing operation process. The team found that the company was only able to produce 143,000 of the 200,000 demand. By applying the Lean and Six Sigma concepts, the current situation in which the company's operations are located is identified by the team and determines the maximum output. The results show that 30% of workers' activities are non-value added activities and that there are many machine delays which cause productivity to decrease. This paper aims to make the printing process more efficient in order to increase the company's competitive advantage [12].

J.E. Guerrero, discuss about implementation Lean Six Sigma in a small furniture company. The company diagnosis is carried out to identify problem of manufacturing process and opportunities for improvement. By applying Lean Six Sigma there is potential to reduce defect by 25 percents and reduce waste 13 percents and also increase sales productivity 14 percent in a year. Lean Six Sigma strategy is very useful for small wood furniture company. Lean Six Sigma is useful for company that has a poor quality management, lack of procedures, lack of formality and quality records [13].

Maria do Rosario, Joao Pedro and Jose Requeijo by applying the Lean Six Sigma approach can reduce production costs for bolt producers in Portugal. Manufacturing bolts have several characteristics such as size lots and a high level of product produced. In this project, the main cause responsible for stamping machine downtime is analyzed by the researcher. The results of the application of Lean Six Sigma obtained by the researchers were a 50% reduction in the average stock level between two workstations, a 10% increase in the availability of stamping machines and also a 15% increase in hourly production capacity [14].

Mohamed K. Hasan, a welding factory applies Lean Six Sigma to reduce waste, improve the manufacturing process and improve the quality of the welding cables produced. In this study, the performance before and after implementing the method to reduce waste was compared. Reducing waste to below 4% which cannot be achieved without using the Lean Six Sigma Methodology is the goal of the company implementing this method. Lean Six Sigma is proven to be a capable tool in the case of waste reduction [15].

Basant Chaurasia, uses a Lean Six sigma approach to the automotive industry in India to increase first through (FTT) and reduce scrap. Increasing the economic growth of automotive companies is a goal the company wants to achieve by applying the Lean Six Sigma approach. The results of research conducted with the Lean Six Sigma approach showed that there was an increase in NTP of 21.21%, an initial decrease of 12.80% within 15 months. By implementing Lean Six Sigma, companies can make the automotive production process more feasible, and eliminate waste and reduce variation or disability [16].

Antonio M.H. Pereira discusses improving the production process in the Mold Industry by applying the Lean Six Sigma approach. There are several activities that extend the time of the production process such as waiting activities which can be seen after mapping the value streams that the researchers found in this study. Therefore, the company makes improvements using the Lean Six Sigma approach to reduce waiting times, production process times, and setup times which will add to planning tasks. The results obtained after implementing Lean Six Sigma show that the operator is not available by 16.4%, machine settings by 14.4% and tool changes by 12.4% and has increased by 20%. There are many benefits obtained by implementing Lean Six Sigma in the mold industry such as reducing waste and producing value-added products for customers [17].

Tan Ping Yi, discusses the use of the Lean Six Sigma approach in Automotive Electronic component assembly plants. The high cost of production, the high number of defective products and the many losses due to the loss of electronic components are the problems found in this company. The tools and techniques used by the Lean Six Sigma approach consist of 5S, Value Stream Mapping, Pareto Chart, Process Control Statistics (SPC), Cause and Effect Analysis, Brainstorming and Poka-yoke. Some of the benefits gained by the company such as quality and communication increased

significantly, reducing electronic component losses by 18% to \$ 6,400 in 16 weeks and also significantly reducing production costs by applying the Lean Six Sigma approach [18].

Chen and Lyu explain the use of Lean Six Sigma in Touch Panel Manufacturing in Taiwan. improving the quality of the touch panel so as to increase customer satisfaction regarding price and product quality, and also to increase the yield rate are the reasons behind the company adopting Lean Six Sigma. The first thing the company does is create a Voice of Customer (VOC) then carry out a cause and effect analysis, create a SIPOC diagram, analyze it with a Pareto diagram, take measurements using Statistical Process Control, and DOE. After the company implemented the Lean Six Sigma methodology, the company obtained a reduced product defect from 32.4% to less than 15%, lowering product costs and increasing customer satisfaction. The development of experience and knowledge of LSS members regarding advanced statistical training such as experimental design because DOE is a key success factor during the improvement phase. The process capability analysis of the stamp process yields a Cpk of 2.34 and a Ppk of 2.25, implying that the process has reached the Six Sigma quality standard [19].

Thomas, explained some researchers in this study that researchers have improved and developed the use of Lean Six Sigma in small engineering companies for its validity using the Lean Six Sigma approach. By implementing Lean Six Sigma, researchers use several tools to make improvements such as Value Stream Mapping, Total Production Management, Statistical Process Control, Quality Function Development, Experimental Design and 5S. The results of the researchers get from this study is to get the potential savings over £ 29,000, can increase OEE cells 11% from 34 50 55%, can increase production 31% / hour from 15 to 25 pph, reduce 12% in energy usage per year, reducing equipment downtime by 3% from 5% to 2%, being able to compete in a market that has experienced a significant increase, increasing customer satisfaction and increasing awareness of statistical techniques for problem solving [20].

Kumar discusses the application of Lean Six Sigma in the manufacture of car accessories. The high number of defects in finished products causes decreased customer satisfaction and the existence of scrap and rework which makes the company have to pay more for rework costs, and there are some non-value added activities that are the company's problems. Techniques used by the company are current state map, Total Production Management, Voice of Customer, and analyzed with pareto analysis, control chart, and for improvement using 5S and FMEA. Implementing Lean Six Sigma defect reduction resulted in significant financial savings of \$ 46,500 per year, reduced machine downtime by 5% from 6 to 1%, 25% reduction in processing inventory saved more than \$ 33,000 savings per year, \$ 20,000 earned saved due to reduction of work accidents as a result of housekeeping procedures, key performance metrics have improved significantly, process capability, first-time yield (FTY), Improve overall equipment effectiveness (OEE), reduction of customer complaints, machine installation time, workplace accident [21].

Aulia Ishak, R. Ginting, and V. Chandra explained about Lean Manufacturing that at least there are some advantages to using Lean Manufacturing compared to other approaches. These advantages are to achieve a large gain in profit, be able to reduce waiting times, be more flexible and responsive, and be generally a better business. identify activities that are classified as waste are the benefits of using the problem solving method using the Lean Manufacturing approach. Based on the results of observations and measurements, it is found that there is a non-value added activity of 296.46 minutes with a process cycle efficiency level of 49.01%. Increase in Manufacturing Lead Time to 489.47 minutes and Process Cycle Efficiency to 58.21% are the results of the improvements obtained [22].

Su, Chiang, and Chang explain that they have conducted case studies on help-desk service companies in the field of information technology. The authors found that implementing a firm's LSS reduced service time by almost 52%, while reducing operating costs was the main result [23]. In the same study, Su, Chiang, and Chang made a list of benefits and some differences between lean and Six Sigma, as discussed in Table 2.

**Table 2.** The benefit of lean and six sigma

Methodology	Six Sigma	Lean
Benefits	Defect Product	Less human effort
	Uniform Process Output	Work in process reduction
	Product/Service Development	Space Saving
	Customer Satisfaction	Productivity improvement
	Culture Change	Less Equipment needed
	Productivity Improvement	Cost reduction
	Market Share Growth	Shorten delivery time
Challenges	Cost Reduction	Cycle time reduction
	System Interaction is not considered because Processes are improved independently	Statistical or system analysis not valued
	Long project duration	People issues
	Lack of specific speed tools	Process incapability and instability

### 3.4. Benefits of implementing Lean Six Sigma

By reviewing 15 papers that discuss Lean Six Sigma that have been published in various industries in eight different countries such as India, Canada, Brazil, UK, US, Singapore, Portugal and Taiwan, it is proven that the Lean Six Sigma method helps these companies with good implementation and success. The benefits of implementing Lean Six Sigma in various industries include:

- Reduce waste
- Reduce defect
- Reduce cycle time
- Reduce Cost
- Improve Quality
- Improve Productivity
- Increase Profit
- Increase Financial saving
- Increase customer satisfaction
- Increase Production Capacity
- Increase production speed
- Reduce inventory
- Reduce Breakdown time

### 3.5. Gap and Agenda for Future Research

These are the gaps from the Lean Six Sigma Articles:

- Among workers and managers still have a lack of awareness about the needs and importance of Lean Six Sigma.
- Lean or Six Sigma or synergy, namely LSS is chosen by most organizations on the grounds of improving the quality of the company. However, using Lean Six Sigma as a tool is not part of a holistic use. In addition, there are no clear guidelines for organizations regarding LSS in different discussions.
- Improve supply chain performance and how the long-term relationship by implementing Lean Six Sigma
- The main driver for organizations to survive, grow and maintain competitiveness is by implementing Lean Six Sigma and its relationship with innovation

- Increase productivity, quality, and customer satisfaction with suppliers.
- Environment.
- Explore the relationship between LSS and the environment by implementing Lean Six Sigma and environmental management systems (Green LSS).
- By integrating Lean Six Sigma with other philosophies such as supply chain, agile manufacturing, sustainability, and environmentally friendly engineering can help Green
- Provide better assistance in research so that participants can more easily understand the concepts and assistance that can be done efficiently in multidisciplinary
- Application of Lean Six Sigma for public sector organizations, for example the health sector, education, council, police and so on.
- Create a Learning Environment for the Lean Six Sigma and Phase Appropriate Training stages (project charter, control chart, etc.) for each phase (DMAIC, acronym for Defining, Measuring, Analyzing, Improving, and Controlling).
- In various industries found Presence of Lean Six Sigma. However, most industries such as agro, food, construction, education and pharmaceuticals require strong Lean Six Sigma Work demands for approval of changes in their critical activities.
- The absence of a general model for implementing Lean Six Sigma is an important issue for most industries and there is no clear definition of the use of tools at various phases of Lean Six Sigma implementation.

#### 4. Conclusion

Six Sigma and Lean are excellent continuous improvement methods that aim to achieve customer satisfaction. These two methods complement each other and can be integrated to form a better method, the Lean Six Sigma method that can overcome the shortcomings of each methodology.

This paper contains the definition of Lean Six Sigma and contains an overview of 22 Lean Six Sigma studies during 2006-2019. This review focuses on the time distribution of Lean Six Sigma Journal, tools on Lean Six Sigma, application of Lean Six Sigma in various industries, the benefits of implementing Lean SixSigma and Gap and Agenda for Future Research.

- This paper comes from various countries such as India, Singapore, Malaysia, Taiwan, China, Canada, Brazil, UK, USA, Portugal. This shows that Lean Six Sigma is carried out throughout the world
- This research was obtained from Elsevier, Science Direct, Emerald Insight, Taylor and Francis, Inderscience database. In total there are 22 articles discussed in this paper relating to the application of Lean Six Sigma
- Lean Six Sigma is mainly focused on various industries. Lean Six Sigma techniques are often used in various industries such as recycling industries, airline companies, healthcare, furniture companies, bolts manufacturers, automotive industries, mold industries, automotive electronic components, touch panel manufacturing, small engineering companies
- This paper also describes the tools and techniques most commonly used in cases in studies included in research. tools and techniques used such as 5S, Value Stream Mapping, Cause and Effect Analysis, Pareto Chart, and DOE
- In addition, many gaps in the Lean Six Sigma literature have now been identified such as the absence of the Lean Six Sigma framework and the lack of research in the relationship between Lean Six Sigma and organizational learning. Therefore the future research agenda for Lean Six Sigma has been suggested in this study

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