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Lean Six-Sigma Approach for Sub-Contract Licensing and its Process Improvement across the Manufacturing Supply Chain using GUT Priority Matrix

Veera Pandiyan Kaliani Sundram[1], Farha Ghapar[2], Mohd Firdaus Osman[2], Chew Li Lian[3], Azlina Muhammad[4]*
[1]Universiti Teknologi MARA, Faculty of Business and Management, Selangor, Malaysia
[2]Universiti Poly-Tech Malaysia, Kuala Lumpur, Malaysia
[3]Binary University, Binary Business School, Selangor, Malaysia
[4]Universiti Teknologi MARA and Universiti Teknologi Malaysia, Malaysia
veera692@uitm.edu.my, farha@kuptm.edu.my, mfirdaus@kuptm.edu.my, lilian@binary.edu.my, azlina59@uitm.edu.my*

Abstract: This study aims to examine how Lean Six Sigma as a quality management tool could enhance productivity in a manufacturing organization, ZITRON. In addition, this study also aims to show how DMAIC (defined, measured, analyzed, improved and controlled) is operationalized for overall process improvement in ZITRON manufacturing. Lean management takes care of waste across all processes and focuses on speed and time within a firm while Six Sigma is a strategy that focuses on eliminating defects, reducing costs and also reduces process variability. As such, this study utilizes the Lean Six-Sigma approach as a tool to ensure more efficiency is achieved in terms of source, make, delivery and process efficiency. Methodologically, there are five phases in the Lean Six Sigma strategies which are defined, measured, analyze, improve and controlled (DMAIC). The findings show that Lean Six Sigma can help to eliminate waste, and cost-reduction, and help eliminate variations in processes within the manufacturing. However, SIX SIGMA tools have been used to solve the problem which is a delay in processes in manufacturing. Based on this research paper, focuses on the manufacturing problem which is a delay in processes. By using Six Sigma, the problem that existed in manufacturing has been solved through process improvement. This work is originally following a self-method in which the data is collected by using observation techniques to identify the existing problem and solution-seeking within the manufacturing.

Keywords: *Lean Management, Six Sigma, Supply Chain Management, DMAIC, Quality Improvement*

1. Introduction

Lean Six Sigma is a tool and it is also known as a strategy that helps to reduce overruns and repair cycle time if the tool is effectively integrated within a firm. The first is lean management, which takes care of waste across all processes and focuses on speed and time within a firm while Six Sigma is a strategy that focuses on eliminating defects, reducing costs and also reduces process variability. Therefore, Lean Six Sigma is a tool or strategy that can improve flexibility, cost and process efficiency (Andersson et al., 2006). In addition, to become a successful firm in a market, the firm needs to have something more than a fast delivery while it is of high quality at a minimal cost (Andersson et al., 2006). For the firms to satisfy customer needs, it is a must for the firms to have a balanced combination of their firm's objectives as well as satisfying customer needs. Moreover, lean or lean manufacturing's main idea is also to minimize waste through efficient products that can be achieved with a comprehensive approach. For instance, eliminating excessive production and inventory, waiting and delays, over-processing, rework and corrections. Therefore, lean or lean manufacturing can minimize waste through efficient production.

Six Sigma is a methodology that originated in Motorola manufacturing and the manufacturing uses the DMAIC method which stands for Define, Measure, Analyze, Improve and Control for process improvement (Sundram et al., 2016). The DMAIC is the philosophy that allows manufacturing to make customer satisfaction its top priority. Six Sigma's main objective is to treat the existing deviations in the processes (Vatumalae et al, 2022). While the purpose of this study is to examine how Lean Six Sigma as a quality management tool could enhance productivity in ZITRON manufacturing. As a business process that allows companies to drastically improve their bottom line by designing and monitoring everyday business activities and also minimizing waste and resources (Andersson et al., 2006). Nowadays, most organizations have implemented and developed Six Sigma programs within their manufacturing and across their supply chain. (Andersson et al., 2006).

2. Literature Review and Theoretical Foundation

Lean Manufacturing: The main focus or components of lean manufacturing is the standardization methods of working, making all employees involved and committed, keeping a focus on what the customer wants, and delivering the right quality at the right time, at a minimum cost (Pascal, 2002). Lean also focus on the fundamental of customer value driven and is a continuous improvement process and this is what it makes appropriate for the distribution process. In this theoretical foundation, lean includes five phases (Venanzi, et al., 2017).

Lean manufacturing comes from the Toyota production system in the 80s. From the Toyota production system in the '80s, this methodology has two central points which are removing activities or processes that will not add any value and adding more value as much as possible. The main focus of lean manufacturing is to eliminate excessive waste such as waste of equipment, materials, parts, space and time. This is because lean manufacturing is intended to keep a minimum amount of usable materials, parts, space and time. For instance, the focus is to eliminate "anything other than the minimum amount of equipment, materials, parts, space and time which are essential to add value to the product (Sundram et al., 2016; Bakar et al., 2016). Lean also enables the improvement of the flow of every management-included process and therefore, automatically removes waste and unwanted activities (Venanzi et al., 2017). Moreover, the manufacturing of Toyota has been investing in people is more necessary rather than investing in a lot of big machinery. This is because the manufacturing of Toyota realized that it is more important to invest in people such as continuing employee training throughout the organization as a way to reduce cost and eliminate possible waste. As a result, this inspired and motivated more employees and also will be able to improve the process within the manufacturing. There are conceptual definitions and measurements of lean manufacturing in then factors quantified by the manufacturing of Toyota such as:

- Supplier feedback: Supplier feedback is critics, feedback performance of products and services received from the customers to the suppliers to ensure there is an effective transfer of information.
- Just-in-time (JIT) delivery by suppliers: Required quantity of products that needs to be delivered by the suppliers at a certain time when the customers needed them.
- Supplier development: Suppliers developed along with the manufacturer, to avoid a mismatch or inconsistency.
- Customer involvement: Customers are the main drivers of each and any business, and it is compulsory to meet their requirements and needs.
- Pull production: An initiation of need from the successor through Kanban should enable the flow of production from the predecessor.
- Continuous flow: Focusing on organizing a continuous flow only through the production and should be established in the factory.
- Setup time reduction: Least setup time is required to adapt resources for variations in products.
- Total productive: Prevent any failure of machines and equipment by doing periodical maintenance procedures.
- Statistical process control: The quality of products is important and no defect should be included in the process.
- Employee involvement: Employees with adequate motivation and entitlement can contribute to the firm.

Six Sigma: The Six Sigma was developed by Motorola in 1980 as one of their strategies to increase their profits and as well as improve the effectiveness and efficiency of operations (Meza & Jeong, 2013; Venanzi et al., 2017). Six Sigma is important, especially for operating systems. This is because it can direct the entire organization to the same end. For example, meeting the customer demand or requirements and aligning the process within the manufacturing (Bhargava, 2010). As a result, meeting the customer demand or requirements, aligning the process and client is a fundamental principle to achieve the objective of having better results in a continuous improvement cycle. Moreover, most of the manufacturers are looking at the SIX SIGMA principles to significantly improve operational efficiency and quality, while facilitating compliance (Abdullah & Rawan, 2018). Thus, in this research paper, there are three main focuses of definition ranges which are error processes to customer satisfaction processes and outcomes and their focus is to improve operations. The neutral of this technique is to reduce costs (Abdullah & Rawan, 2018). In SIX-SIGMA, there are five phases of methodology which are defined, measured, analyze, improve and controlled (DMAIC). The tools of Define, Measure, Analyze, Improve and Control (DMAIC), there are commonly used such as SIPOC, boxplot, capability studies, statistical process control, measurement system analysis, cause and effect diagram, cause and effect analysis, data collection, hypothesis testing, regression, and brainstorming (Narula & Grove, 2015). In the Define, Measure, Analyze, Improve and Control (DMAIC), the phases were to use the tools to analyze and achieve better results. Table 1 displays the Define, Measure, Analyze, Improve and Control (DMAIC) descriptions.

Table 1: Descriptions of Define, Measure, Analyze, Improve and Control (DMAIC)

PHASE	DESCRIPTION
Define	During this defining phase, the main objective is to define and analyze processes or products that need to be improved. For example, defining the most suitable team members or certain members to work with the improvement, defining the customer needs and requirements, based on the internal and external customers and creating a map for the improvement of the process.
Measure	Next, in this measuring phase, the recognition of key factors is a must that key factors that have the most influence on the process. As a result, the deciding needs to be done because it is a need to decide on how to measure them. This is to ensure that the data can be collected to clarify the sources of process variation.
Analyze	Third, analyzing the factors that are necessary to be improved after that it can reduce the factors of process variation.
Improve	In this improvement phase, there is a need to design and also implement the best and most effective or suitable solution. For instance, Cost-benefit analyses should be used to identify the best solution to assure improvement.
Control	Last but not least, after the implementation was successful and also the improvement maintains over time, it is compulsory to use control tools such as a control plan for effective monitoring.

The Define, Measure, Analyze, Improve and Control (DMAIC) helps the firm to manage and lead projects which are supported by the leaders that can generate a safe and visible result for system improvement.

Lean Six Sigma: Lean Six Sigma is the latest generation that has been used by many firms regarding their business improvement methodology. Lean Six Sigma is based on the two concepts of lean manufacturing and SIX-SIGMA. Moreover, it is also based on two previous philosophies lean manufacturing and SIX SIGMA and adopts effective aspects of these respective approaches (Mousa, 2013). In addition, lean manufacturing and even SIX SIGMA techniques, it is a tool that has been used to get a better of the two methodologies which can increase speed and as well as increasing accuracy. Thus, it can help employees in organizations to understand the importance of Lean Six Sigma in determining most of the manufacturing projects (Sreedharan & Raju, 2016). However, there are some of the Lean Six-Sigma benefits as presented in Table 2.

Table 2: Benefits of Lean Six-Sigma Implementation

Lean Six-Sigma Benefits	Explanation
Reduce cost	It can reduce the cost of being a poor quality within the firm.
Quality of product	The quality of the product would be good quality after implementing Lean Six Sigma.
Eliminate waste	It eliminates waste within the processes such as removing non-value-adding steps (waste) in the critical business process.
Meet customer demands or requirements	Ensuring that the services or products the firm provides meet the customer's needs because the customer voice must always be the priority.

Lean Manufacturing and SIX-SIGMA have the same purpose to satisfy customer needs and demands while also improving critical business processes, nonetheless, lean manufacturing and SIX SIGMA each serve different areas of quality (Sreedharan & Raju, 2016). For instance, lean manufacturing's main purpose is to remove activities that do not add value to the business however, SIX SIGMA strives to make the business maximize its productive performance. The scope of Lean is to create a setting to improve the flow and eliminate waste which is approaching ensures smooth and uninterrupted product flow through the organization to produce only what is required by the customer (Anthony & Kumar, 2012). Nevertheless, the SIX SIGMA relies on the suitable selection of projects for both the organization and the customer. The integration of Lean and SIX SIGMA aims to focus on every opportunity for improvements. The Lean Six Sigma methodology is also preferred by many quality excellence methodologies, especially in the service industry (Sunder & Antony, 2018; Ali et al., 2020). There are interconnections between lean and SIX SIGMA as presented in Table 3.

Table 3: The Interconnections between Lean and SIX SIGMA

LEAN MANUFACTURING	SIX SIGMA
Lean manufacturing is wide and it compromises the whole thing.	SIX-SIGMA is complex and its main focus understands the details.
Improve capacity.	Improve the situation by using define, measure, analyze, improve and control (DMAIC) tools.
Focus on continuity and value chain.	Focus on controlling capability to meet customer needs and demands.

Therefore, Lean Six Sigma gives a lot of benefits to the firm or organization to make sure that the firm or organization can achieve its goals such as gaining customer loyalty and continuing to increase the effectiveness and efficiency of critical business processes. In addition, SIX SIGMA was more data-oriented and lean was more to applying principles that are based on knowledge and experience (Antony et al, 2017; Smetkowska & Mngalska, 2018).

3. Research Methodology

This study involves one particular manufacturing organization which is ZITRON, located in Kuala Lumpur, Malaysia. This research includes an improvement of performance regarding the firm or manufacturing management. This organization is selected based on the current prevailing issues of process inefficiency in the manufacturing setting, primarily focusing on the delay in processes. Therefore, to resolve this issue, a SIX SIGMA project was initiated. DMAIC methodological approach was carried out to further investigate the processing delay and its root cause. This quality management method, DMAIC investigates the issues from various perspectives across the manufacturing supply chain which includes supplier, input, process, output and customers (Selvaraju et al., 2019). The data is tabulated using the Suppliers, Inputs, Process, Outputs, and Customer (SIPOC) diagram to ensure that the problem can be recognized from certain processes in the manufacturing supply chain.

Subsequently, the GUT priority matrix is used to rank the importance of issues and tasks to streamline company operations. The GUT priority matrix is used to complete tasks according to their importance. Gravity, Urgency, and Tendency, or GUT, are the characteristics that structure the sequence of work. In an organization, new demands are always arising. Although some businesses still function under this urgency-driven mentality, these conditions can result in poor performance and overworked employees. Having an order of priorities and working with a basis on the urgency and importance of actions is essential in establishing a task schedule without overloading employees. As such this study was purported to examine how Lean Six Sigma as a quality management tool could enhance productivity in ZITRON manufacturing. In addition, this study also aims to show how DMAIC (defined, measured, analyzed, improved and controlled) is operationalized for overall process improvement in ZITRON.

4. Results

According to the researcher's findings and discussion, for the researcher to have findings and discussion, the researchers conducted a SIX SIGMA methodology which has five different phases as mentioned above which are Define, Measure, Analyze, Improve, and Control (DMAIC). The researcher will observe the manufacturing's main problem which is a delay in processes in ZITRON Manufacturing and try to implement the Define, Measure, Analyze, Improve and Control (DMAIC) as a tool to improve critical business processes such as eliminating a range of errors within the processes and also focus on improving the operating system to ensure that the ZITRON Manufacturing meets the customers or contractors needs and requirement regarding their contract license. Last but not least, the researcher will use the Suppliers, Inputs, Process, Outputs, and Customer (SIPOC) diagram as a tool to have an output of this research work.

a) Define Phase
Problem statement: Delay in processes through the online system in ZITRON Manufacturing. Based on the problem statement above which is a delay in processes through the online system of ZITRON Manufacturing. The manufacturing had an issue regarding the delay in making the contractor's license. For instance, approximately one to five months or more for the contractor's license to be fully completed. As a result, some of the contractors would be dissatisfied regarding the processes in ZITRON Manufacturing as they could not do any work without the license. In addition, although there is an online system, the contractor's application for their license would also take a few months. Table 4 is the Suppliers, Inputs, Process, Outputs and Customer (SIPOC) diagram.

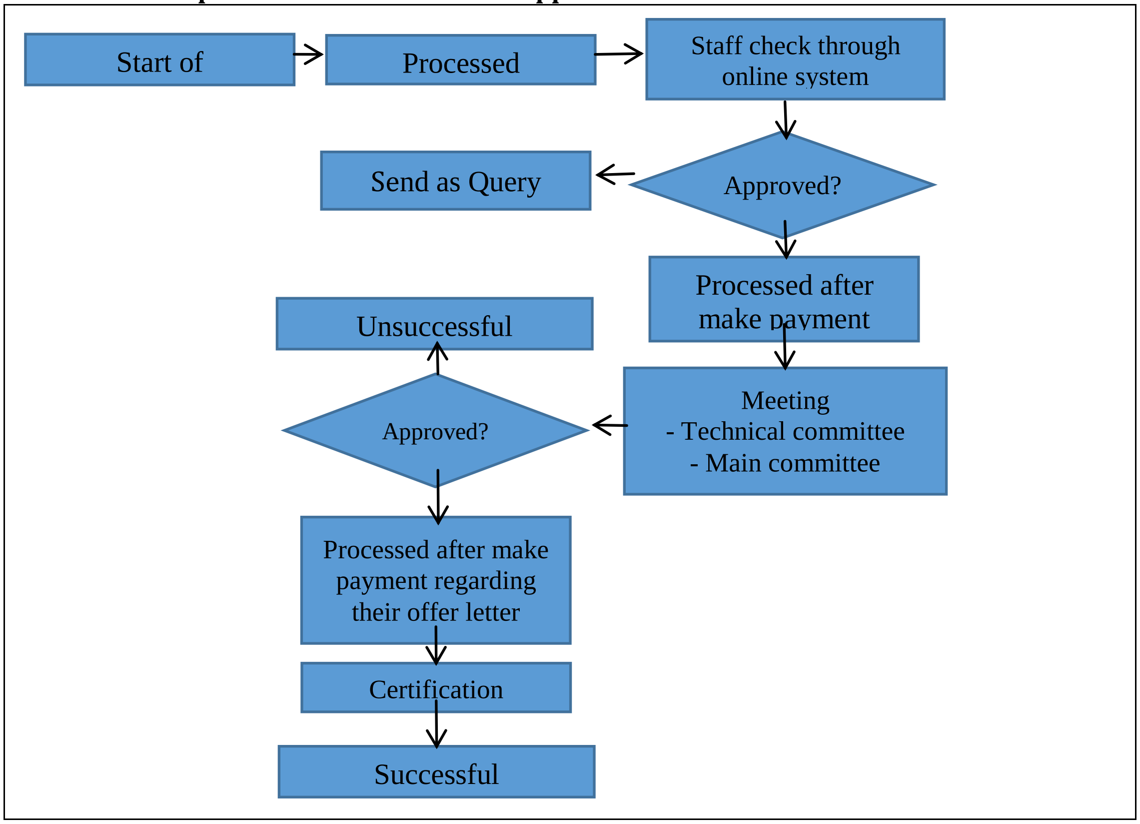
Table 4: Suppliers, Inputs, Process, Outputs and Customer (SIPOC)

SUPPLIERS	INPUTS	PROCESSES	OUTPUTS	CUSTOMERS
Who supplies the process inputs?	*What inputs are required?*	*What are the major steps in the process?*	*What are the process outputs?*	*Who receives the outputs?*
Contractor/Customer	Application	Application through the online system	Availability of certified license	Contractor
Local Authority	Trading license	Checking the trading license topic	Availability of Certified license	Contractor
Customs Department [only for tax and licensed manufacturing warehouse]	Certificate of Customs	Checking the Grade and validity of Customs	Availability of certified license	Contractor
Bank and Other Financial Institutions	Bank Statement	Checking the latest and updated money amount	Availability of Certified license	Contractor
Ministry of International Trade and Industry	Bumiputra Status Certificate	Checking the validity of the certificate	Availability of certified license	Contractor
Energy Commission (Only for electrical works)	Competency Form	Checking the validity of the license	Availability of certified license	Contractor

b) Measure
After brainstorming regarding the problem statement and making a Suppliers, Inputs, Process, Outputs, and Customer (SIPOC) diagram to identify the potential root causes of delay in processes in ZITRON Manufacturing, it is a need for the researcher to establish the effect they have on the process and also how these kinds of things are to be measured. For instance, areas that needed to be measured as below;

- When does the contractor make their application 'specific date'?
- The waiting time for the contractor's application is to be discussed during the upper meeting.
- The waiting time for the contractor's application to get payment details regarding their certified license certificate.
- The waiting time for the contractor's Certified license certificate to successfully be made after payment (usually 30 to 45 days of working hours).

Figure 1: Process Map of the Certified Contract Application



c) Analyze
The next step was to analyze the factors that contributed to the delay in processes in ZITRON Manufacturing and find the areas that are needed to be addressed in the measure phase for the researcher to be able to find the root causes of delay in processes in ZITRON Manufacturing. After successfully analyzing and finding the problem of delay in processes in ZITRON Manufacturing, the next step was to design the best solution for the problem which solution should be effective and efficient. By using Lean and SIX SIGMA tools and methods the following changes needed to be implemented as below;

- Cooperate with the main customer to repair the system faulty regarding some of the contractor's application process malfunctions.
- Include more employees to process the certificate.
- Make ideas for business customers to make an online system payment on the certified website.
- Provide training to all of the employees and contractors.
- Meeting with the main committee twice a month for the contractor's new application.

d) Improve
After the implementation of the effective and efficient solution, the delay in processes was successfully reduced. The outcome of the delay in processes is very few after the implementation of the solution. Most of the applications through online systems are quite smooth and there is no fault regarding their application. Table 5 represents the GUT Priority Matrix for this improvement phase.

Table 5: The Gravity, Urgency and Tendency (GUT) Priority Matrix

Problem	Gravity	Urgency	Tendency	GxUxT	Rank
Process delay	5	4	4	80	2
A breach in the online system	3	2	3	18	4
Infrastructure problem	4	3	3	36	3
Lack of workforce	5	5	4	100	1
Lack of technology skills among USER	2	2	3	12	5

e) Control

Controlling the online system is a must such as cooperating with the Sabah State Computer Services Department to ensure that there is no fault regarding the contractor's certified application. To improve lead times, increasing staff in ZITRON Manufacturing helps to solve the root cause of delays in processes in manufacturing.

Table 6: Process Step and Action Plan in the Control Phase

Process Step	Control Item (Input/ Output)	Control Methods	Responsibility	Specification Limits/ Requirements	Response Plan
Checking documents through the online system	Input - system fully functional	Metric	Information Technology	100%	Train employees on how to check documents.
The Administrative Officer approves an application through the online system	Input - system fully functional	Metric	Information Technology	Variable - dependent on the number of applications	The Administrative Officer must accept approval within a short time.
Sub-Contractor applications going through the meeting.	Output - List of successful customers' online application	Audit	Contractor	Variable - dependent on the number of applications	Meeting twice a month with the committees.
The Administrative Officer issues an offer letter through the online system	Input - system fully functional	Metric	Information Technology	Variable - dependent on the number of applications	The Administrative Officer must accept approval within a short time.
Processing certificate	Output - Documentation of each customer's certificate	Audit	Employees	100%	Adding more staff in charge of certificate production.

5. Conclusion

ZITRON Manufacturing is a focal firm (main) manufacturer in Kuala Lumpur, Malaysia. This manufacturer provides a valid and approved license to all of the subcontractors so they can do their work as manufacturing contractors. Without the license which is also known as the Certified Contract Licensing, the contractor cannot execute any work. This is because having a knowledgeable and trustworthy contractor to do the work is important. This process helped countless contractors to enable them to apply for a contractor license through the seamless application process. Since the facoal firm manufacturer, ZITRON is integrated well with other parties in the manufacturing supply chain, it took quite a long time for the contractor to complete the required documents required by the manufacturer. This study discovered how the Lean Six Sigma strategy could improve flexibility, cost-efficiency, and agility within the processes in manufacturing. Nevertheless, in this research paper, there is only Six Sigma as a tool to make an analysis regarding the delay in processes in Unit Certified and use the Six Sigma tool to solve the problem. This is because the SIX SIGMA and DMAIC can resolve delay in the certification process. For instance, the contractor-certified license application through the online system is very slow and took about three to five months until they can get their license. This will probably ease the contractor's business and also ease the contractor to use the certified license to work. However, the SIX SIGMA tools needed to be implemented extra carefully because it is also involving various parties across the manufacturing supply chain. For example, from the define phase, the researcher needs to do a Suppliers, Inputs, Process, Outputs, and Customer (SIPOC) diagram to ensure that the problem can be recognized from certain processes in the business. From this, it could help the researcher to obtain data easily from the Suppliers, Inputs, Processes, Outputs, and Customer (SIPOC) diagram. Last but not least, each of the Define, Measure, Analyze, Improve and Control (DMAIC) phases are necessary to do by the researcher to achieve an effective and efficient output.

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