AN APPLICATION OF DMAIC CONCEPT TO IMPROVE DELAY DELIVERY: A CASE STUDY OF JAPANESE CAR MANUFACTURING COMPANY

By

PAPATSORN SANITRAT

Submitted in Partial Fulfillment of the Requirements for the Degree of

MASTER OF SCIENCE IN SUPPLY CHAIN MANAGEMENT

Martin de Tours School of Management and Economics

Assumption University

Bangkok, Thailand

June, 2018

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Declaration of Authorship Form

I, Papatsorn Sanitrat, declare that this project and the work presented in it are my own and have been generated by me as the result of my own original research.

AN APPLICATION OF DMAIC CONCEPT TO IMPROVE DELAYED DELIVERY: A CASE STUDY OF JAPANESE CAR MANUFACTURING COMPANY

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7. None or parts of this work have been published before submission.

Signed Papatsorn S.

Date 29-June-2018

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ADVISOR'S STATEMENT

I confirm that this project has been carried out under my supervision and it represents the original work of the candidate.

Signed _____

(Dr. Srobol Smutkupt)

Date _____

ACKNOWLEDGEMENT

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Papatsorn Sanitrat
Assumption University
June, 2018

ABSTRACT

This study is a case study of a Japanese car manufacturing company. The company was facing with delayed delivery from suppliers. The objectives of this research were to identify problems, find solutions and implement appropriate actions to improve delivery performance of suppliers. Recommendations, solutions, and preventive actions were provided to improve the delivery performance of the suppliers and prevent recurrent problems.

This research applied the DMAIC (Define-Measure-Analyze-Improve-Control) approach to define the problems, measure the current performance, analyze the root causes of the problem and identify the improvement of current process. The researcher also suggested an improvement plan with recommendations in order to achieve sustainable process of operational improvement of the company.

The result, after implementing the improvement plan, has shown significant improvement in delivery performance of the suppliers. The four major root causes which were order over forecast, capacity machine, capacity manpower and material and finished goods shortage had been reduced; therefore, the delivery performance of the suppliers was improved. The company still needs to have continuous improvement to develop process to be more efficient. This is to ensure a sustained improvement to be carried out with practical monitoring to prevent recurrent problems.

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I, _____, have proofread this project entitled AN APPLICATION OF DMAIC CONCEPT TO IMPROVE DELAYED DELIVERY: A CASE STUDY OF JAPANESE CAR MANUFACTURING COMPANY and hereby certify that the verbiage, spelling and format are commensurate with the quality of internationally acceptable writing standards for a Master's degree in Supply Chain Management.

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CHAPTER I

GENERALITIES OF THE STUDY

This chapter provides the overall background information about factors of delayed delivery from suppliers affecting both customer and supplier. The background of the study and research objectives of this study have also been discussed, as well as statements of problems occurred in conducting this research, and the scope and limitations of the research. Moreover, this chapter also studies the factors of delayed delivery from suppliers which influence from both customer and supplier, and the operational definition of terms used in this research have also been shown.

1.1 Background of the Research

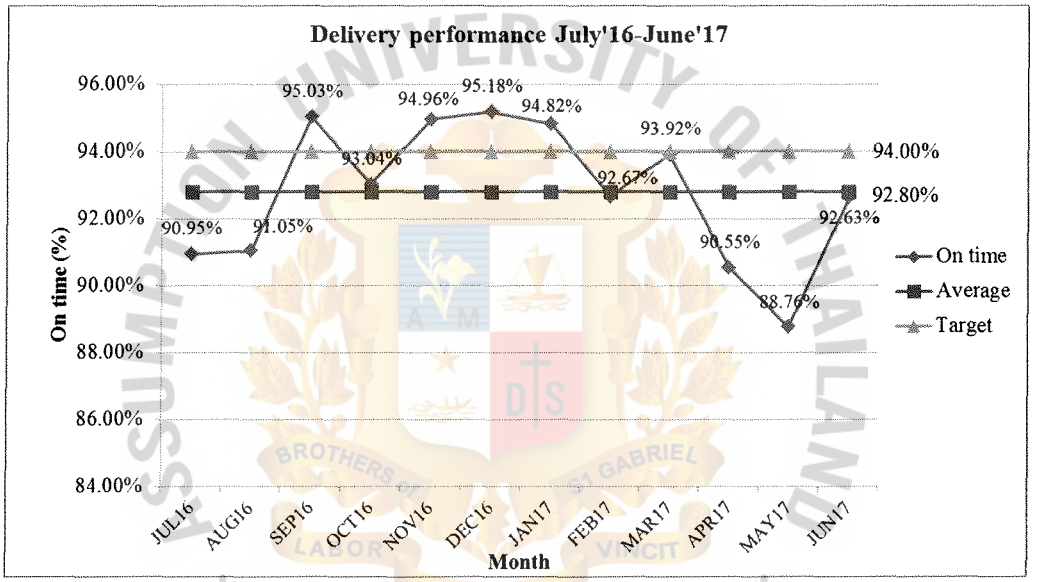
ABC Company is a famous Japanese car manufacturing company, which it currently manufactures cars in 20 countries around the world, such Asia, Europe, United States of America and South Africa. The company based in Thailand exports vehicle parts overseas to more than 30 countries around the world. There are more than 4,000 employees in Thailand. In addition, the company continues to develop products and deliver highly innovative technology to the customers in various countries and regions around the world.

Currently, there is high competition in automotive market which directly affects the actual sales and sales plan, which the company needs to adjust its sales plan in order to support the market demand. In addition, the production plan has been affected and has to be adjusted accordingly. Moreover, ABC Company always faces with the problems of delayed delivery from suppliers affecting both customer and supplier and it is the cause of delayed delivery to warehouse and delayed shipment to export the parts to overseas customers. By this research, the researcher would like to find the appropriate method to improve the root cause of delay.

1.2 Statement of the Problems

ABC Company has problem about on-time delivery from suppliers, which is lower than KPI target of 94% on-time delivery as shown in Figure 1.1. The average result of the on- time delivery is only 92.80%.

Figure 1.1: Delivery Performance during July'16-June'17



Source: Adapted from Company's data

ABC Company has found that there are many factors that affect delayed delivery, which occurs from ABC Company, customers, 3PL and suppliers as indicated in Table 1.1.

Table 1.1: Root Causes of Delayed Delivery during July'16-June'17

Arise from	The root cause	(%)
Customer	Order over forecast	47.95%
	Order over capacity	5.47%
	Plan not Balance	5.76%
3PL	3PL mistake	0.91%
Supplier	Capacity manpower	7.24%
	Transportation delay	1.84%
	Machine breakdown	4.38%
	Capacity machine	11.17%
	Material and FG shortage	5.82%
	Quality	2.62%
	Human error	4.41%
ABC company	New model	1.11%
	Unpacking	1.30%
	Total	100.00%

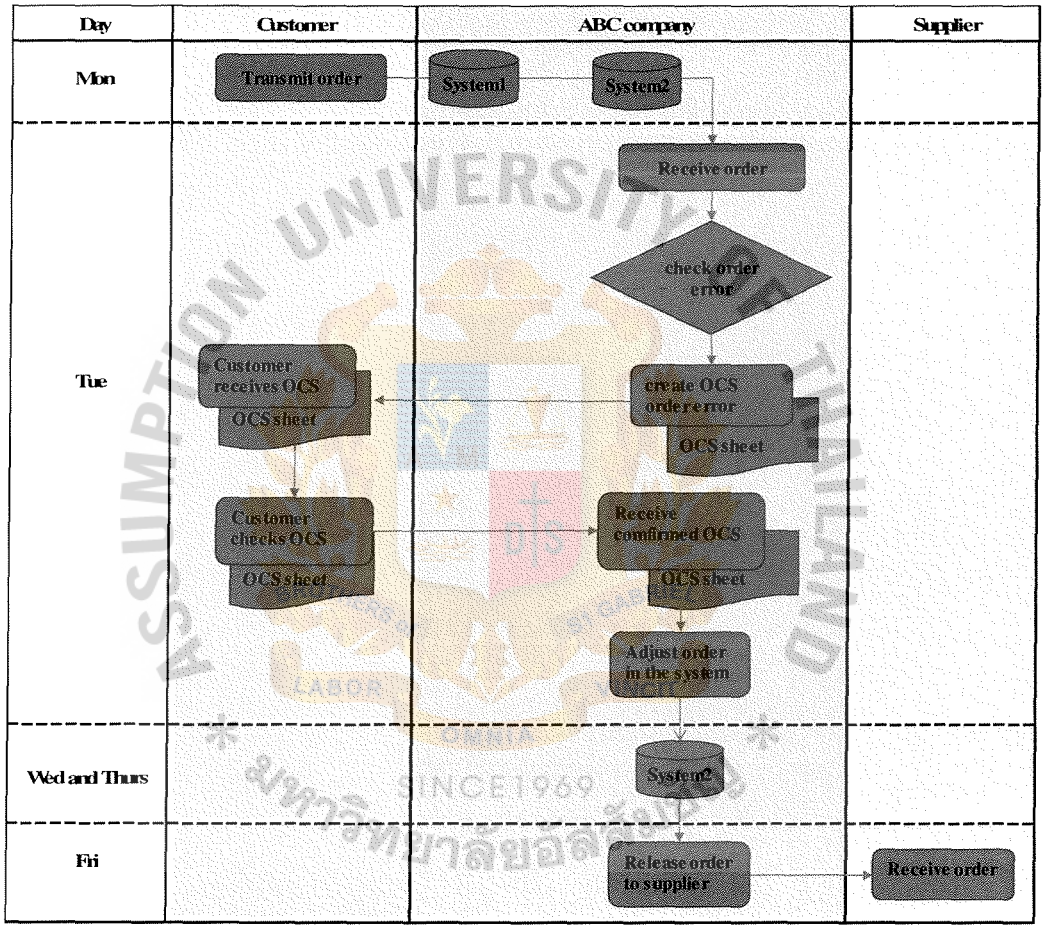
Source: Adapted from Company's data

In order to improve order over forecast which arises from customers, the company has to review the whole ordering process. Figure 1.2 shows AS-IS process of ordering which the ABC Company receives an order from customers via Electronic Data Interchange (EDI) system. After that, the staff checks the order for any error and fix it, then adjust the order in the system. Finally, the order is released to the supplier.

The current ordering process receives order via EDI system automatically and receives order in the system directly and only the staff can check for any order error. If there is no tracking order, there is a problem in identifying the increase or decrease in the order. Therefore, order fluctuation has an impact in both internal and external operations. Internal operation refers to warehouse operation in terms of manpower, area

preparation, and packing materials. External operation will affect directly the suppliers to prepare materials, packaging and transportation.

Figure 1.2: AS-IS Process of Ordering



Source: Author

After reviewing the current process, the company realized that it lacks of tracking order before releasing the order to supplier. Besides, ABC Company does not know the trend of order volume. Therefore, the company has to implement some activities to improve the order fluctuation by tracking order in order to increase the perception of the

company, and for the supplier to increase and prepare the readiness to support order fluctuation.

For delayed delivery from suppliers, now it has become the major concern for ABC Company. The company would like to improve the delivery performance of supplier to achieve the target of on-time delivery. The current KPI would like to support customer to get more parts on time in order to fulfill customer demand and increase customer satisfaction. The researcher has concentrated on identifying and solving problems of delayed delivery affecting both customer and supplier.

Therefore, the researcher has conducted the study to find out "How can ABC Company improve delayed delivery from the supplier?"

1.3 Research Objectives

The purpose of this research is to improve supplier's delivery performance in one automotive company. Therefore, the following research objectives are stated as follows:

1.3.1 To apply DMAIC concept in order to find out the root causes of delayed delivery;

1.3.2 To improve ordering process between overseas customers, ABC Company and suppliers; and

1.3.3 To recommend the order fluctuation improvement process.

1.4 Scope of the Research

In this study, the researcher decided to focus on ABC Company in Thailand to examine the factors that affect supplier's delivery performance. The researcher used the secondary data from the company collected by system. The researcher studied and analyzed the root causes of delay from historical data and monitored the delivery performance after implementing the improvement plan. The researcher examined the

AS-IS process to eliminate non-value added activity and increase the necessary process to increase and improve the current problem, which the study is based on the Define-Measure-Analyze-Improve-Control (DMAIC) tools used to reduce delay delivery and improve ordering process. The literature review that supports this study provides evidence that the tool, data and facts provided would assist in the understanding of the root causes and could reduce delayed delivery from suppliers. The researcher collected the data of delivery from suppliers during September 2017 to March 2018 to evaluate the results.

1.5 Significance of the Research

This study conducted by the researcher can be useful for the automotive companies faced with similar problem in this industry. This research is the application of the DMAIC concept to identify the root causes of the problem and help the company to gain better understanding of current process. Moreover, this research also provides the improvement of current process of ordering on the areas that it lacks and needs to be improved. It gives the idea as what the company should do in order to improve the current ordering process. New designed process supports both suppliers and customers to increase awareness of ordering trend and improve information flow. Lastly, this research can also act as a reference to other researchers conducting a similar study.

1.6 Limitations of the Research

Even though the researcher has been thorough in the preparation of this research, there are certain limitations and shortcomings.

Firstly, the research focused on only ABC Company because of the availability of information and time constraint. Secondly, the researcher analyzed the root causes of delayed information from suppliers of ABC Company by using the historical data during July 2016 to June 2017. Finally, the researcher implemented an improvement plan during September 2017 to March 2018 and summarized the results in April 2018.

1.7 Definition of Terms

Critical to quality (CTQ)	is a tool to help satisfy a key customer or process requirement of any product, process, or service characteristic. Each characteristic has to be measurable, such as speed, accuracy, timeliness, and cost (Shaffie & Shahbazi, 2012).
DMAIC:	is a root cause analysis tool and methodology to solve problem consisting of five steps which are Define, Measure, Analyze, Improve and Control (Shaffie & Shahbazi, 2012).
Electronic Data Interchange (EDI)	is to exchange information in intercompany processes, such as purchase orders and invoices, in a structured electronic format easily processed by computers. This helps to automate and streamline business by eliminating or simplifying clerical tasks, speeding information transfer, reducing data errors, and eliminating business processes (Myerson, 2012).
Pareto analysis	is 80/20 rule which can identify that 20% of the known causes are considered as effect 80% of outcomes. In another meaning, it helps to specify the problem that should be solved (Craft & Leake, 2002).
Supplier, Input, Process, Output, and Customer (SIPOC)	It is a tool for identifying customers of a process. Moreover, it helps to make the project boundaries and scope more understandable (Brue, 2015).

Voice of customer (VOC)	is the sound of customer that presents customer's expectation or requirement from the suppliers (Brue, 2015).

1.8 Chapter Summary

This chapter introduces the problem of ABC Company, which is a famous Japanese car manufacturing company. The current problem is KPI of on-time delivery from suppliers, which is lower than KPI target of 94%. The researcher focused on studying and finding out the root causes by applying DMAIC approach.

CHAPTER II

REVIEW OF RELATED LITERATURE

This chapter discusses about the selected literature review related to this study. Theories, tools, methodologies and techniques which are selected to describe in this chapter will support to identify root causes of delayed delivery and find out the way to improve the delivery performance.

This study mainly focuses on the definition and concept of DMAIC methodology which is a problem-solving tool. DMAIC is used to identify the root causes, which have many factors that affect delayed delivery. Moreover, DMAIC is one of the various methods used for continuous improvement to increase customer satisfaction, used to reduce delayed delivery, and improve current process to make the process better than the previous one. Business improvement can use DMAIC process to improve delivery performance by creating or revising process, which is discussed in the next section.

In addition, the researcher has used various tools to analyze the root causes and improve current process in order to improve delivery performance. The three main tools which are Pareto analysis, Process map and Run chart were used in this project.

The related literature and concepts which are explained in the next section are DMAIC (Define-Measure-Analyze-Improve-Control), Value added, Non-value added, Necessary Non-value added activities, and various tools, such as Pareto chart analysis, Process Map/Process Flow chart, Brainstorming and Run chart.

2.1 DMAIC (Define-Measure-Analyze-Improve-Control)

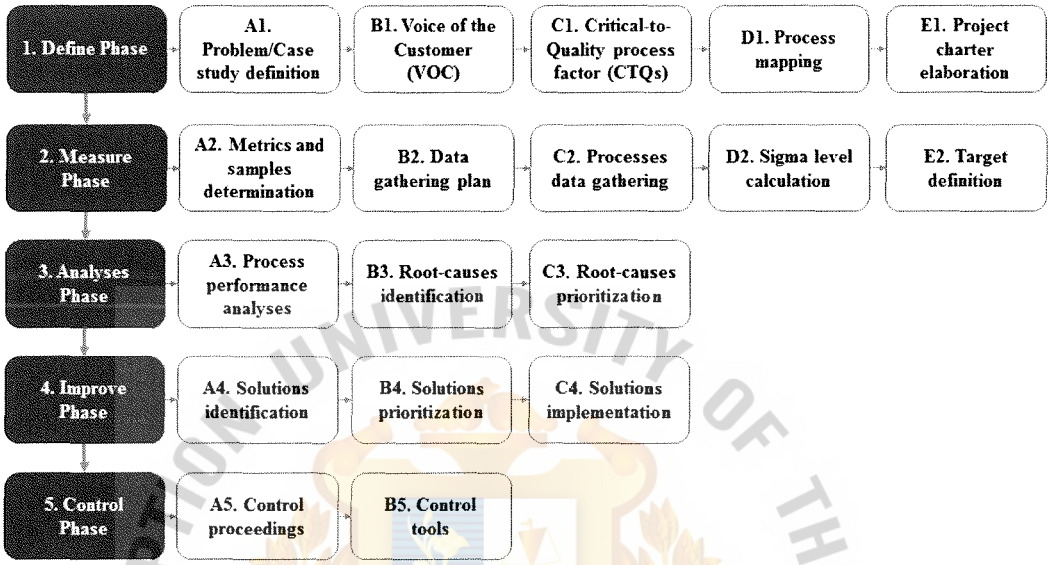
According to Marques and Matthé (2017), DMAIC is similar to a roadmap of Six Sigma methodology which was structured for continuous improvement of existing process, product or service. Moreover, DMAIC is known as effective problem-solving

methodology which requires high collaboration among the project teams and team work to work in order to achieve goals. In addition, Shaffie and Shahbazi (2012) also stated that DMAIC is a root cause analysis tool and a problem-solving methodology. It consists of five steps which are Define, Measure, Analyze, Improve and Control. Each phase of DMAIC includes a set of tools which represents Kaizen or continuous improvement (McCarty, Daniels, Bremer & Gupta, 2005).

Ismyrlis and Moschidis (2018) pointed that the measurement of results is measured in various units, such as cycle times, product quality, product delivery, on-hand inventory, productivity measurement, and supplier performance in order to measure whether the target is achieved following the plan, company target, profitability, market share and others.

Figure 2.1 demonstrates each essential process of DMAIC approach, which is sequenced as Define-Measure-Analyze-Improve-Control including details and effective tools in each phase.

Figure 2.1: DMAIC Process



Source: Tenera and Pinto (2014)

The following part describes more details of each phase in DMAIC approach in order to provide better understanding of the objectives and those involved in each process - Define-Measure-Analyze-Improve-Control.

2.1.1 Define Phase

The first step "Define phase" is very important by mainly focusing on problem identification. Moreover, the project scope, purpose, resource, guideline and goals are clear within project team. Besides, customers' requirements or Voice of customer (VOC) is specified in order to translate the VOC into Critical to quality (CTQ) statements. Then high-level process flow "SIPOC" is used to display supplier-input-process-output-customer diagram (Shaffie & Shahbazi, 2012).

In Define step, the highlighted problem is selected to be solved or addressed. The information is needed to be gathered in order to analyze the root causes by using Pareto

analysis which is commonly used to identify the few vital problems to be solved (De Feo, 2017). Tenara and Pinto (2014) and Prashar (2014) stated that in define phase, which is the first step of DMAIC approach, the main problem should be clarified. The project charter with all required information, defining the CTQ of customer point of view and current process mapping are needed to be created in order to identify and solve the problem in the next phase.

The researcher followed the step in define phase to identify the problem with the project team and created guideline for project charter. More details are discussed in the measure phase.

2.1.2 Measure Phase

In the previous step, define phase has completely identified the problem. Then, the next important part is the measure phase which aims to gather the necessary data. In preparation of data collection, this step is needed to collect consistently accurate, precise and related information which the project team could use to analyze the right root causes (Shaffie & Shahbazi, 2012).

Prashar (2014) pointed that this measure phase consists of process mapping of current process, measurement system analysis or MSA, data collection plan. The data collection plan describes the data collection details, such as the data type, sample size, data collection method and responsibilities.

2.1.3 Analyze Phase

After problem identification and data collection are done in the previous phase, the next important thing in analyze phase is to find the exact root causes of the problem in order to have more understanding of the existing process condition (De Feo, 2017). Shaffie and Shahbazi (2012) also stated that analyze phase focuses on taking collected data to identify the root causes of the problem. In this phase, various tools are applied, such as histogram, run chart, box plot, Pareto analysis, value added, non-value added, necessary

non-value added analysis and other tools to improve the process to be more appropriate and standardized.

Prashar (2014) pointed that in this analyze phase, the project team implements benchmarking and baseline methods to see the performance and then apply powerful tools and techniques, such brainstorming and Pareto analysis for identifying the improvement plan.

In this study, the researcher applied the suggested tools from the literature, such as run chart, Pareto analysis, value added, non-value added, necessary non-value added analysis to identify the root causes of the problem and clarify the details of the process to analyze for process improvement to be implemented in the Improve phase.

2.1.4 Improve Phase

The Improve phase aims to improve ways of the existing process to be better. Moreover, improve phase starts from implementing the improvement plan developed by the project team from various ideas to create improvement plan (Shaffie & Shahbazi, 2012). Cheng and Kuan (2012) stated that this phase starts to test new probable methods or process created from the brainstorming of the project team for improvement.

In this study, the researcher focused on process improvement using various tools, such as brainstorming, value added, non-value added, necessary non-value added analysis with process mapping to identify and improve the current process. The details of improve phase are discussed in the next section.

2.1.5 Control Phase

The last step of DMAIC approach which is control phase is focused on how to maintain and sustain the improvement plan which has already been implemented (Shaffie & Shahbazi, 2012). Prashar (2014) also stated that the purpose of control phase is to sustain the improvement of the process suggested by the project team. Moreover,

this phase is used to track and monitor process variation which has been implemented. For process control, it is maintained by using control tools (Cheng & Kuan, 2012).

In this study, the researcher used run chart to track and monitor. If there was any abnormal situation during the process implementation, the project team would take action immediately which are discussed more in details in the next part.

2.2 Value added/Non-value added/Necessary Non-value added Activity

Value added (VA), Non-value added (NVA) and Necessary Non-value added (NNVA) analysis are lean tools used to standardize the process by identifying and eliminating variation. Value added, Non-value added and Necessary Non-value added activities support to find the true value of each process step from the customer's perspective (Shaffie & Shahbazi, 2012).

De Feo (2017) stated that lean is used to identify and eliminate waste. The main value focus is customer's value. For the things that did not create any value to customer was considered as waste. The fundamental question for Value added and Non-value added analysis is "Is the customer willing to pay for this?" It was asked for each process step what could be done for customer and what waste should be eliminated together. However, some of Non-value added activities were still required to keep in the process such as inspections or other quality checks. This activity would remain in place to ensure customer satisfaction until the process could be made robust enough not to require the non-value-added activity. Similarly, Myerson (2012) also stated that there are Value added, Non-value added and Necessary Non-value added activities. For the process that customer was willing to pay was Value-Added activity. On the other hand, the process that did not provide any value to customer was Non-value added activity. Moreover, for the required process that needed to have but no value was Necessary Non-value added activity.

2.3 Tools (Pareto chart analysis, Process Map/Process Flow chart, Brainstorming and Run chart)

Delayed delivery has given negative aspects to KPI and customer satisfaction of ABC Company. Therefore, ABC Company requires tools to identify and find out the root causes of delayed delivery problems and to analyze the causes in order to improve in the next step. After that, the company would find solution and improve delivery performance to increase on-time delivery.

In addition, the researcher used various tools to analyze the root causes and improve current process in order improve delivery performance. The next part describes the tools that were used in DMAIC process. There were four main tools that were used to identify and find out the root causes, improve process and delivery performance, such as Pareto chart analysis, Process map, Brainstorming and Run chart

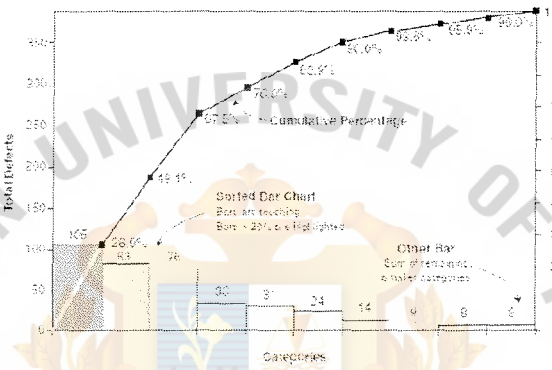
2.3.1 Pareto Chart Analysis

Pareto chart is a powerful tool for controlling quality and identifying problems by ranking the highest potential effect to the lowest effect. Pareto principle is often termed as the "80/20 rule" because 80 percent of abnormal things in the system result from only 20 per cent of the possible causes. The first priority is to focus 20 percent of causes because of limited time and resources (Fotopoulos, Kafetzopoulos, & Gotzamani, 2011).

Sahoo and Sahu (2014) also stated that Pareto chart is plotted as scale in picture of histogram in vertical bar graph. Then, the root causes are shown and easy to understand in graphical way by prioritizing the attention to the correct problem. Pareto analysis is used to prioritize the root causes, which the results of a Pareto analysis are typically shown in a Pareto chart. The Pareto chart represents variety of factors or problems under consideration in ranked order (Cervone, 2009).

Pareto chart is a popular tool used to identify and prioritize problems. Also, Pareto chart divides each effect into the "vital few" things. Figure 2.2 shows the anatomy of a Pareto chart which has normally two or three bar charts on the left side representing the major problem (Arthur, 2016).

Figure 2.2: The Anatomy of a Pareto chart

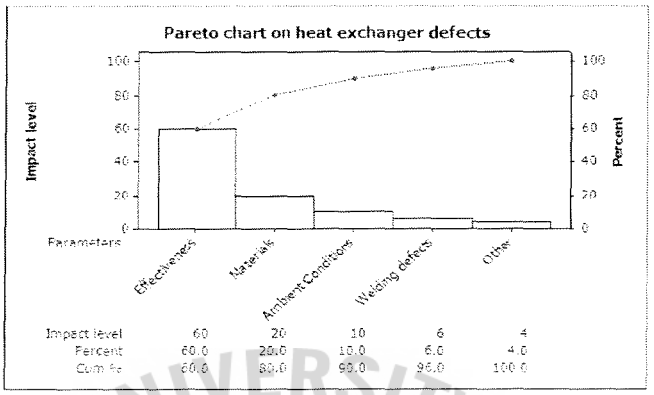


Source: Arthur (2016)

Fotopoulos et al. (2011) stated that "in practice, the Pareto principle is commonly used in marketing and sales contexts, customer complaints, in quality control and manufacturing deficits, and in other business settings."

According to Srinivasan, Muthu, Devadasan and Sugumaran (2014), Pareto chart is used to identify and disclose the factors that influence the heat exchanger performance. Figure 2.3 shows that the effectiveness of shell and tube heat exchanger has the highest impact to the heat exchanger performance. After that, the factors are prioritized to solve.

Figure 2.3: Pareto Chart on heat exchange defects



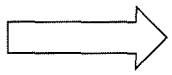
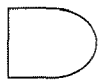
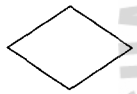
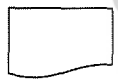
Source: Srinivasan et al. (2014)

The researcher also used Pareto chart to identify and prioritize the problem in this project. However, the researcher focused on the top rank problem because of limited time and resources to implement this project.

2.3.2 Process Map/Process Flow Chart

Process map is a graphical flow to represent the series and sequence of process and demonstrate the linkage among input, output and task in the process (De Feo, 2017). Process map is used to develop existing process for the process which is under study in order to improve the process in the future. Moreover, the advantage of the process map flowchart makes people easily understand the activities in the process and it makes clear relationship in the process (Yang, 2005). Table 2.1 represents the symbols of the process flow chart where each step is represented by a symbol to explain its function.

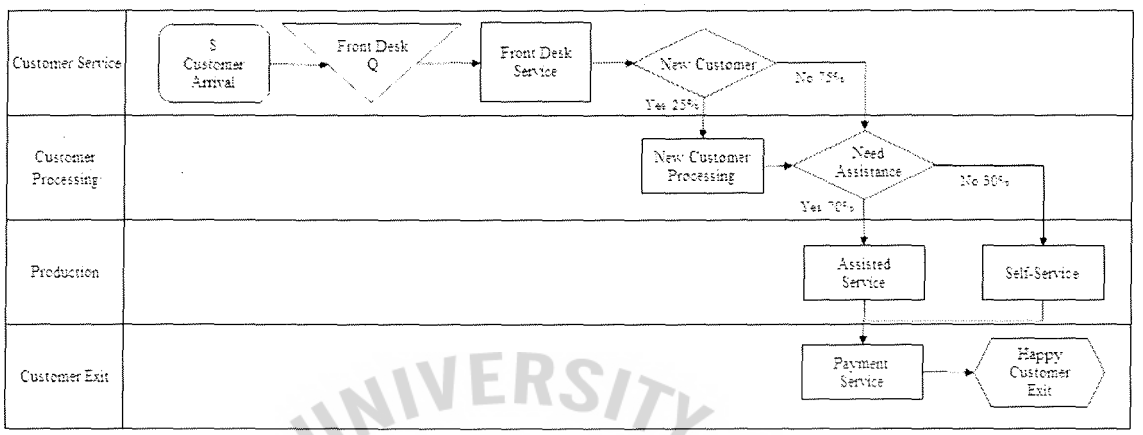
Table 2.1: Symbols of Process Flow Chart

Symbol	Name	Activity Represented
	Boundary (start or end)	Identifies the beginning or end of a process. Start or End can be written inside.
	Activity or task	Identifies an activity or task in the process that changes input. Usually, the name of the activity is written inside.
	Movement or transportation	Indicates movements of outputs between locations.
	Inspection	Identifies that the flow has stopped in order to evaluate the quality of the output or to obtain an approval to proceed.
	Delay	Identifies when something must wait or is placed in temporary storage.
	Storage	Identifies when an output is in storage waiting for customer.
	Decision	Identifies a decision or branch point in the process
	Document	Identifies when the output of an activity is recorded.
	Database	Identifies when the output of an activity is electronically stored.
	Connector	Indicates that an output from this flowchart will be input to another flowchart.
	Arrow	Indicates the sequence and direction of flow within the process and usually transfer an output of one activity to the next activity.

Source: Yang (2015)

Moreover, a process map is a picture document to show the series of process. It displays the movements of activities and objects, information or materials, so each step could be analyzed. Deployment of swim lanes process map would be useful to see more clearly the specific stakeholder in the process flow in order to help in the analysis step by step (Keller, 2011).

Figure 2.4: Swim Lane Process Map



Source: Keller (2011)

The researcher applied process map in this study to improve current ordering process and identify what activity is needed to add or eliminate for better process flow. The new process flow is discussed in the next chapter.

2.3.3 Brainstorming

Brainstorming is group thinking and it is a popular method used to generate new concept and new ideas from group of people (Buggle, 2003; Litchfield, 2008). Moreover, when having brainstorming, it should be cross-function team meeting in order to get various ideas from different perspectives and knowledge of each team. Besides, brainstorming could help to create new solution and ideas to solve the problem, disclose idea outside the box, and achieve increasing productivity in particular operation. Also, the question in brainstorming should be an open question to ask such as "What are all the ways we could possibly...?" (Buggle, 2003).

Levine, Alexander, Wright, and Higgins (2015) pointed that even brainstorming helps to stimulate group of people to generate creative ideas. On the other hand, the past research stated that brainstorming could make productivity loss in two ways, such as coordination loss and motivation loss. It could occur when participants share their ideas

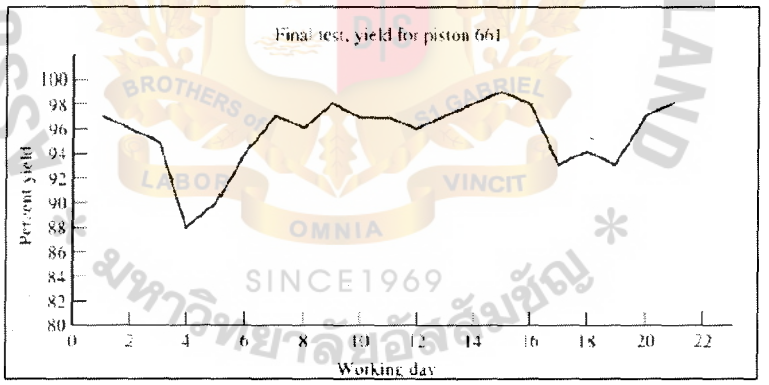
and when they run out of ideas, it would decrease their motivation and performance. Meanwhile, the situation which is opposite by not forcing to generate all ideas and has more flexibility, the participants would increase their motivation and performance.

The researcher applied brainstorming approach in Analyze and Improve phases of DMAIC in order to gain more ideas and improve the current ordering process.

2.3.4 Run Chart

The run chart is a graphical tool to demonstrate historical data plot versus time displayed in Figure 2.5. The run chart shows the movement trends, cycles, and other changes over time similar to time series tracking (De Feo, 2017).

Figure 2.5: Example of run chart



Source: De Feo (2017)

Moreover, run chart is one of the powerful tools used to monitor or track the change in performance over time in the process improvement. The advantage of run chart is having baseline to track performance since the beginning step to monitor changes in performance or process over period of time. It also helps to compare the previous and new performance clearly (Shaffie & Shabazi, 2012).

The researcher applied run chart in Define phase and Control phase to see the performance of delivery in both current process and after the new process was implemented. A more detailed discussion is explained in the next section.

2.4 Review of Previous Research

Mishra and Sharma (2014) used DMAIC to improve the process and performance following a systematic methodology. This study formed cross-functional team which was production quality; marketing departments to identify the critical to quality (CTQ) characteristics during the production process of paint. Several tools like brainstorming, Pareto analysis, and cause and effect analysis were used to identify, prioritize the issues and find effective solutions to solve the problem. Applying the DMAIC method helped to reduce defects for shrinkage from 15.44% to 6.32%.

Kumar and Sosnoski (2009) applied DMAIC Six Sigma process to examine and improve the quality issue. The purpose was to find a way to reduce and improve the amount of warp incurred in Amada A-Station punches during the heat-treat process and realize cost. Brainstorming, process mapping, fish-bone diagrams, histograms, and control charts were used in this study. The results after implementing DMAIC approach were the scrap and operation reduction, increasing the product quality and cost reduction. This project could create cost saving more than millions of dollars and increase in profit by 2 percent of company's annual revenue.

According to Karout and Awasthi (2017), the DMAIC is the effective problem solving and systematic method for eliminating unnecessary processes or errors and improving efficiency. DMAIC method was applied with "RK" Company, which is one of the fast growing software development companies in Canada. The company used CTQ, SIPOC, Pareto analysis, cause and effect diagram and process map to identify the root causes for the large number of bugs found in production and provide improvement. As a result, the company was able to solve the problem of software quality management.
Prashar (2014) stated that an application of Six Sigma DMAIC methodology had been used and showed the success in cost reduction, cycle time improvement, defect

elimination, increasing customer satisfaction and increasing profitability in every industry and various organizations around the world. The company would like to reduce the cost of poor quality (COPQ) in repair division of a helicopter company. The company applied various DMAIC's tools, such as project charter, CTQ, high level process map, measurement system analysis (MSA), data collection plan and others in each phase in order to find out the possible solutions. As a result after implementing DMAIC, the company was able to reduce the rejection rate of cooling fan assembly from 9% to almost 0%, improve internal operation and process, and increase customer satisfaction.

2.5 Chapter Summary

The literature review describes DMAIC approach, which helps to gain a better understanding of the root causes, process improvement as well as the selection of the various tools to be used to effectively support the process improvement and reduce the effect of the existing problems.

The DMAIC problem solving method can help companies to develop and improve ordering processes by applying Pareto Analysis to identify the root causes and propose solutions. The DMAIC approach is used in the next chapter to show the current problems that are causing delayed delivery and determine how to reduce the root causes and then sustain the improvement.

CHAPTER III

RESEARCH METHODOLOGY

This research was conducted to study the problem and find solution to improve the existing problem. This chapter explains the DMAIC methodology by applying various tools in this research to identify the problem and the root causes of the problem. The various tools that have been discussed in the literature review in the previous chapter is the focal point in this chapter by using DMAIC process step by step. Furthermore, Table 3.1 shows the steps of DMAIC process in this study with various effective tools for continuous improvement.

Table 3.1: Steps of DMAIC Process

Phase	Methodology	Tool	Result
Define	Step1: Identify the existing problem from company's KPI and expand collecting feedback from stakeholders	CTQ,VOC, Process map, Project charter	Delayed delivery from suppliers is the problem
	Step2: Form project team and create project charter		Scope of whole project is clear
Measure	Step3: Plan data collection	Data collection	The necessary data is gathered and ready to use in analyze phase
Analyze	Step4: Use Pareto analysis to identify the root causes of delayed delivery	Run chart, Pareto, VA/NVA, Process map	Order fluctuation from customer is the major root cause that affects supplier's delayed delivery
	Step5: Use brainstorming to focus which process should be improved		Current ordering process is reviewed and improved
	Step6: Use process map with VA/NVA analysis to analyze current ordering process whether it lacks of some necessary process and needs to be revised or not.		The current process lacks of order variance tracking, so this process is needed to add for the process improvement

Table 3.1: Step of DMAIC Process

Phase	Methodology	Tool	Result
Improve	Step7: Use brainstorming in project team to create new ordering process and implement to solve the problem	Brainstorming, New process	Improvement plan is created to solve supplier's delayed delivery from order fluctuation
Control	Step8: Use run chart to monitor and control new process	Run chart	The problem is improved and the project team can track delivery performance in each period of time

Source: Author

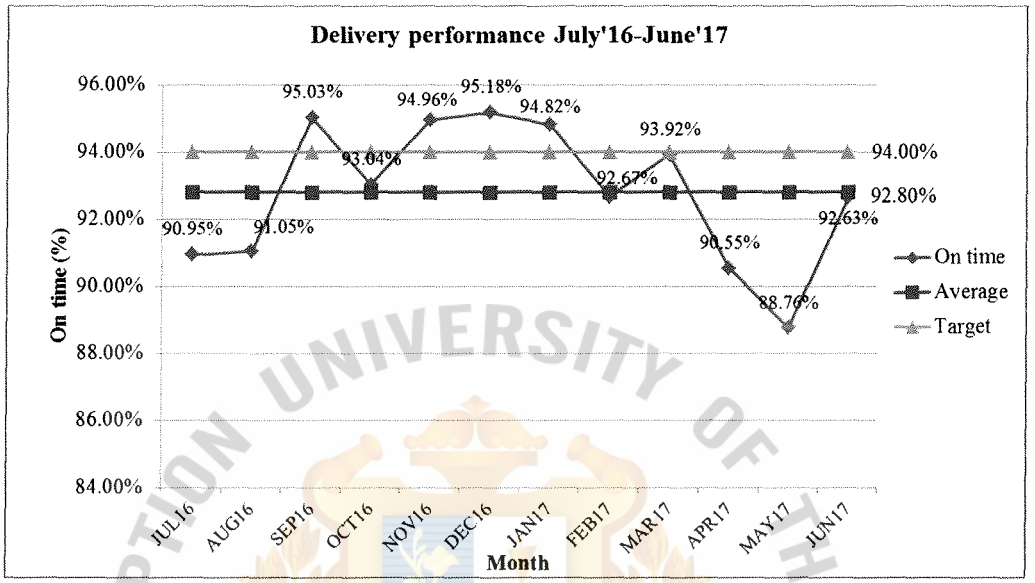
For the data analysis, the researcher used the collected data for analysis with the project team. The project team analyzed all the data by using Pareto chart to identify the main root cause of the delayed delivery from supplier to solve the correct point of delayed problem.

The next section explains more detailed steps of Define-Measure-Analyze-Improve-Control phases that have been implemented.

3.1 Define phase

In define phase, the researcher used the collected KPI information of supplier's delivery performance during July 2016 to June 2017 to identify the problem. Figure 3.1 presents the delivery performance of the supplier during July 2016 to June 2017, which shows high fluctuation and cannot meet the KPI target of 94% on-time delivery.

Figure 3.1: Delivery Performance during July'16-June'17



Source: Adapted from ABC Company's data

Therefore, the related team needed to have a meeting to discuss about this matter including feedback from both teams who took care of customer's side and supplier's side in the previous year, 2016.

In the meeting, the researcher received a lot of feedback from the related team and then converted the feedback into Voice of customer (VOC). Table 3.2 explains the VOC which was translated to CTQ. In this step, it was very important to understand the needs of management, customer and supplier from us. After the researcher converted VOC to CTQ, there were three main parts for concerns, such as management, customer and supplier. The management focusing on KPI of supplier delivery performance should be improved from the past year to meet the KPI target of 94% on-time delivery. For customers who needed to receive the parts on time, they needed to receive the delayed information one week in advance before the parts were shipped out. Also, the suppliers would like to receive the order in advance at least three weeks to prepare the materials, resources for production.

Table 3.2: Translation of VOC to CTQ

Function	Voice of Customer	Critical to Quality
Management	There are many delayed deliveries in FY16 and cannot achieve KPI target.	Supplier's delivery performance should be improved to meet KPI target of 94% on-time delivery.
Customer	There are many delayed deliveries of parts in the past year and there was no pre-information for the delay.	Customers need to receive the parts on time and need to receive the delayed delivery information in one week in advance before the parts are shipped out.
Supplier	Order from ABC Company is always fluctuating and no advance information	Suppliers would like to receive advance information of the order at least three weeks to prepare the materials, resources for production

Source: Author

After the CTQs were identified and reported to the management team, the management team then created a project team to review and improve the problems. Table 3.3 represents the project charter with project name "order management". For business case, supplier's delivery performance must be improved and achieved the KPI target of 94% on-time delivery. Besides the problem statement, the KPI target of supplier's delivery performance did not achieve the 94% on-time delivery and suppliers did not know the ordering trend that was changed in each period of time, so it affected the supplier's delivery performance. To achieve KPI target and share the trend of order to supplier in advance were the goals of this project. The project scope focused on supplier's delivery performance who supplies parts for export. The measurement period of this project was during September 2017 to March 2018. There were four main parties involved in this project: customers, parts ordering team, supply risk management team and suppliers.

Table 3.3: Project Charter

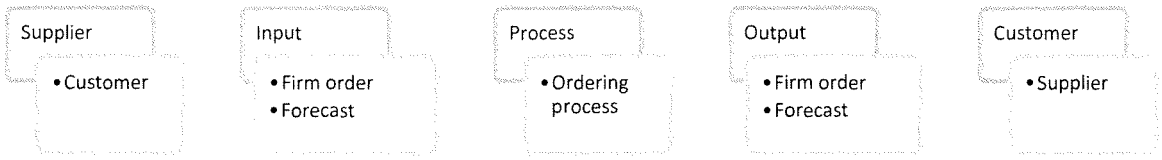
Project name	Order management
Business case	Supplier's delivery performance must be improved and achieved KPI target of 94% on-time delivery because it is the corporate target.
Problem Statement	KPI target of supplier's delivery performance did not achieve the 94% on-time delivery and suppliers did not know the ordering trend that was changed in each period of time, so it affected the supplier's delivery performance
Goal Statement	1) Supplier delivery performance achieves KPI target of 94% on- time delivery 2) Suppliers get pre-information for the parts that have order fluctuation of more than 200% with forecast provided in the previous week before the order confirmation
Project scope	1) The project focused on supplier's delivery performance who supply parts for export 2) The project started and measured the improvement during August'17-March'18
Timeline	Define during June'17 (3rd and 4th week of the month) Measure during July'17 (1st and 2nd week of the month) Analyze during July'17 (3rd and 4th week of the month) Improve during August'17-March'18 Control during September'17-March'18
Responsibilities	1) Customers 2) Parts ordering team 3) Supply Risk Management team 4) Suppliers

Source: Author

After the project team was formed and project charter was completely done. The high level of process or SIPOC was created to display the overall picture of the current process to make the project team to have the same understanding of the current process. Figure 3.2 shows SIPOC of current process. The supplier is the customer to provide information. Input is firm order and forecast. Process is ordering process which the

information comes from the firm order and forecast. Release output is firm order and forecast. Finally, customer in SIPOC is the supplier to receive firm order and forecast.

Figure 3.2: SIPOC of Current Process



Source: Author

3.2 Measure phase

In measure phase, the researcher gathered report data from the warehouse team. The responsibility of warehouse team is to manage the warehouse operations and follow up parts. In case of any delays, the warehouse team requests and collects the reasons of delayed delivery from suppliers.

Moreover, the data collection was the secondary data from the warehouse team of ABC Company. The data gathered consisted of delivery plan, actual delivery dates and reasons of the delayed delivery from suppliers. The delivery data were accurate because they were downloaded from the receiving system. Moreover, the period of data collection was during July 2016 to June 2017. The researcher used one year data to analyze the overall historical delivery and the root causes which could show the significant problems in the past.

The data collected were used to trace the delivery status of the suppliers, whether they were able to deliver the parts on time or not. The key purpose of tracing the status of delivery was to compare between "delivery date" and "actual date" (same as in the table below) to see the delivery status whether it was on time or delayed. Additional required information for more analysis were the data recorded from weekly report which

identified the reasons of delayed delivery. Ultimately, the project team used final report of delivery status combining data from the resulting system and reasons for delay from the weekly report. Table 3.4 displays the final report of delivery status used for analysis in the next step.

Table 3.4: Final Report of Delivery Status

ORG WK.	Customer	parts_no	Qty	Delivery date	Actual Date	Status	Major problem	Arise from	The root cause	Others
WK06	Customer A	100000000101	504	20170206	20170224	Delay	1. Order Over forecast	1.1 Customer	1.1.1 Order over forecast >= 20%	1.1.1.1 Material shortage
WK06	Customer A	100000000101	504	20170207	20170224	Delay	1. Order Over forecast	1.1 Customer	1.1.1 Order over forecast >= 20%	1.1.1.1 Material shortage
WK05	Customer B	100000000102	660	20170203	20170216	Delay	1. Order Over forecast	1.1 Customer	1.1.3 Order over forecast >= 100%	1.1.3.1 Material shortage
WK06	Customer C	100000000103	720	20170203	20170214	Delay	2. No Order Over forecast	2.2 Supplier	2.2.9 Human error	2.2.9.5 Plan production mistake
WK06	Customer C	100000000104	1560	20170203	20170214	Delay	2. No Order Over forecast	2.2 Supplier	2.2.9 Human error	2.2.9.5 Plan production mistake
WK06	Customer C	100000000105	192	20170203	20170214	Delay	2. No Order Over forecast	2.2 Supplier	2.2.3 Material	2.2.3.4 Import material / component shortage
WK06	Customer C	100000000105	192	20170203	20170214	Delay	2. No Order Over forecast	2.2 Supplier	2.2.3 Material	2.2.3.4 Import material / component shortage
WK06	Customer C	100000000106	24	20170203	20170203	Ontime				
WK06	Customer C	100000000106	24	20170203	20170203	Ontime				
WK06	Customer C	100000000107	48	20170203	20170203	Ontime				
WK06	Customer C	100000000107	48	20170203	20170203	Ontime				
WK06	Customer C	100000000108	24	20170203	20170215	Delay	1. Order Over forecast	1.1 Customer	1.1.5 Plan not Balance	1.1.5.1 Fluctuate by Daily
WK06	Customer C	100000000108	24	20170203	20170215	Delay	1. Order Over forecast	1.1 Customer	1.1.5 Plan not Balance	1.1.5.1 Fluctuate by Daily
WK06	Customer C	100000000108	24	20170203	20170215	Delay	1. Order Over forecast	1.1 Customer	1.1.5 Plan not Balance	1.1.5.1 Fluctuate by Daily
WK06	Customer C	100000000108	24	20170203	20170215	Delay	1. Order Over forecast	1.1 Customer	1.1.5 Plan not Balance	1.1.5.1 Fluctuate by Daily

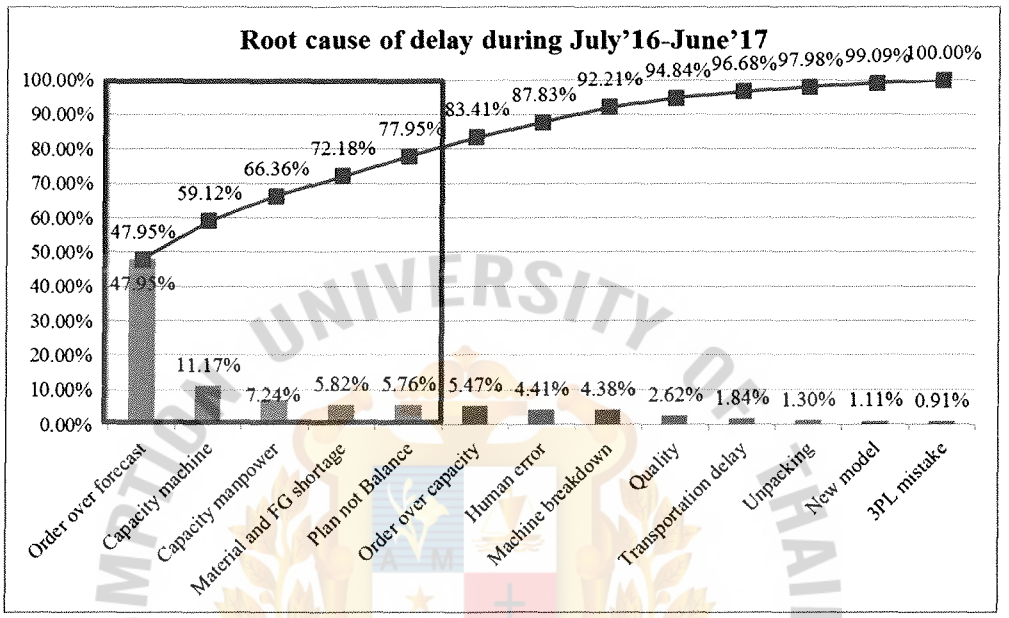
Source: Adapted from Company's data

3.3 Analyze phase

The purpose of analyze phase is to find out the root causes of delayed delivery from the supplier. The following steps are used to identify the root causes.

Firstly, the researcher used the collected information from the warehouse team about delivery plan, delivery actual and the root causes of delayed delivery from supplier's feedback to analyze the root causes. Then the researcher planned a specific action for process improvement because of the limited resources and time. Figure 3.3 shows the Pareto analysis of the root causes of delayed delivery during July 2016 to June 2017 affecting supplier's delivery. The major top five root causes were order over forecast which occurred from customer (47.95%); not enough capacity machine (11.17%); capacity manpower (7.24%); material and finished goods shortage (5.82%); and plan not balance (5.76%) respectively.

Figure 3.3: Pareto Analysis of root cause of delay delivery during July'16-June'17



Source: Adapted from Company's data

The researcher selected the major five root causes to be solved and improved. The project team found out that the ordering process needed to be reviewed and to create some activities for improvement. Therefore, the project team started by studying the current ordering process whether or not any processes could be revised and improved.

After reviewing the current process displayed in Figure 3.4, the order was received from the customer by EDI via system and automatically transferred into ABC Company's system. Then the order was checked for firm order error. The order which was detected as wrong order from customers, such as order wrong quantity mismatch from lot size; order parts which have no data in the system; order wrong part no. from design change which was phased out; and discontinued order of part were created into Order confirmation sheet (OCS). OCS sheet was used to record wrong order and confirm between ABC Company and customer to check and confirm order adjustment in each

ordering round. Then the OCS sheet was sent to customers to check order error. After the customer has completely checked and confirmed order error, the customer sent the OCS sheet back to ABC Company for adjusting the order in the system. After all orders were corrected and all errors were cleared up, the order was transferred into the ordering system to prepare for the release of the order to be sent to the supplier for the next two weeks for delivery plan.

Moreover, this process consisted of both value added and non-value added but necessary activity. Value added activity is a process necessary to have and create value to customers. While, non-value added but necessary activity is a process that might not create value in customer's point of view but necessary to have in order to recheck the correct order.

The main concern of the current ordering process was the company received the firm order and forecast without "order variance tracking process" between checking order error process before creating OCS sheet and adjust order in the system. For current process, when receiving new firm and forecast from customer, ABC Company had only order error checking process (e.g. order quantity mismatch with standard lot size or order part that does not exist in the system) but did not have process tracking variance of order or comparison of order between previous forecast order from last week (N-1 week) and new firm order (N week) before releasing order to supplier.

Then, the order was just only checking for the order error and adjusting order in the system following OCS sheet. Therefore, under the current process, ABC Company would not know the order volume of each part whether it has been increased or decreased. Sometimes, there was wrong input order which was too high from customers but actually they did not want those order volume. Therefore, the company lacks of awareness of ordering trend and checking status of the order.

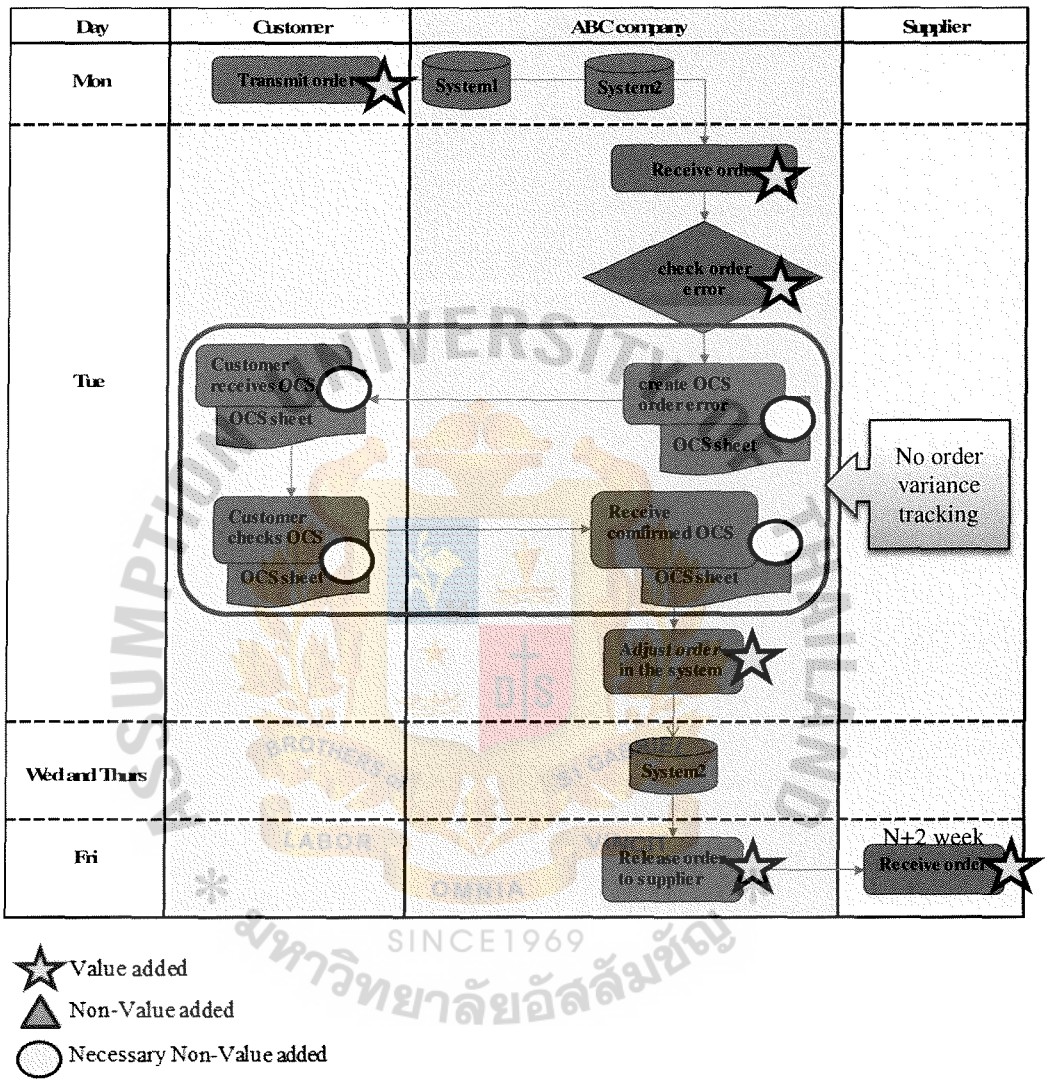
Moreover, since there is no tracking order volume for the new incoming firm order and forecast (N week), so ABC Company would not know the status of ordering volume

and trend as to how much the order has fluctuated. Consequently, ABC Company also could not discuss about volume with customer effectively why the order is increased or decreased. Moreover, the company could not pre-alert information of significant change of order whether how much and why the order is increased or decreased to suppliers and request them to support more parts as well. This cause directly affected supplier's preparation, such as finished goods parts, materials, capacity machine for production, and other resources.

In addition, all suppliers would receive an updated three-month forecast, 1-month forecast and weekly forecast which the forecast data show how much quantity and when the company needs the parts. Then, the suppliers use the forecast data to prepare their materials, manpower, other resources and production plan. Therefore, if the customers suddenly change the firm order without any notice, some suppliers could be able to support to deliver the parts on time because they have high safety stock for order fluctuation, but some suppliers could not support. For those suppliers who could not support, it is because of long lead time components condition, production capacity constraint, manpower limitation and limited warehouse facilities.

Therefore, the missing process "order variance tracking process" was the critical point that the project team has detected and needed to create additional process in the future to track order variance and analyze order volume including pre-alert order that has high fluctuation volume to supplier. More details are discussed in improve phase for next action.

Figure 3.4: Current Process with VA/NVA/NNVA



Source: Author

For unbalance plan order, it was difficult to control because customer needed to input the order by following the vessel schedule. Moreover, there was another constraint of parameter settings of transportation team because they arranged for a truck to pick up the parts from the supplier. After, the system calculated the order with all parameter settings, the order was automatically generated in the delivery plan to supplier, which the user could not control, so this root cause was out of control by the project team.

Therefore, the root causes that the project team could attack were order over forecast, capacity machine, capacity manpower and material, and finished goods shortage. The researcher discusses more how to attack these root causes in the improve phase.

3.4 Improve phase

After analyzing and identifying the root causes from the gathered data in analyze phase, the researcher and the project team created potential activities, innovative processes and solutions to improve delayed delivery from the major root causes. The goal was to initiate effective improvements of ordering process to increase awareness and pre-information of order to suppliers to increase their preparation time and reduce delayed delivery. In the next section, the researcher discusses the new designed process and methods that the project team has created and implemented in order to reduce delayed delivery causing from order over forecast, capacity machine, capacity manpower and material, and finished goods shortage.

3.5 Control phase

Control phase mainly focuses on how to sustain the new designed process in order to improve and reduce the percentage of delayed delivery from suppliers. Moreover, delayed delivery from suppliers may be reduced by increasing awareness and pre-information to suppliers. If the process works well, the delayed delivery from suppliers will be improved and the KPI target will be achieved.

3.6 Chapter Summary

This chapter explains the methodology which researcher has used in each phase. The problem is identified and the project team and the project charter are developed in define phase. The necessary data are collected in Measure phase to use in analyzing the root causes of supplier's delayed delivery in analyze phase. Moreover, the improvement plan is created to maintain the new process and control the performance in improve and control phases.

CHAPTER IV

PRESENTATION AND CRITICAL DISCUSSION OF RESULTS

From the DMAIC methodology, the researcher has already completed three phases which consist of define phase, measure phase and analyze phase. In define phase, the researcher has reviewed the KPI of supplier's delivery performance during July 2016 to June 2017. The average result has shown that supplier's delivery performance was lower than the KPI target. In measure phase, the researcher collected necessary information to analyze the root causes of the problem. In analyze phase, the researcher has found the root causes of the problem by analyzing the collected information. The four major root causes which have been selected to improve were order over forecast, capacity machine, capacity manpower and material, and finished goods shortage.

This chapter presents the improve phase and control phase of DMAIC method. The improve phase is to identify the solutions to improve the root causes, implement appropriate actions and validate results. The control phase is to ensure that the improved actions are continued and sustained as well as the ongoing performance is monitored continuously.

4.1 Improve phase

The root causes of the delayed delivery from suppliers were shown in the previous chapter. Next is the improve phase, the researcher found that the current process was needed to improve and additional activities were needed to initiate to address the problem.

Moreover, before launching the new improved process, the project team had to set up a meeting with part ordering team (PO), supply risk management team (SRM), customers and suppliers. This is to make agreement and ensure that the potential actions must be implemented and coordinated effectively.

There are three actions that need to be done in improve phase: (1) Set meeting with all customers (2) Set meeting with all suppliers, and (3) Design new process.

4.1.1 Set meeting with all customers

In order to start the new process and new activities with all customers, the project team set a meeting with customers to explain the new process which affected the customers. The purpose of the meeting was to explain what information that ABC Company would provide to customers and what information that the project team would like to get back from the customers. Importantly, the project team would like to emphasize the time and necessary information that all customers needed to give feedback because of the time constraint of ordering system.

4.1.2 Set the meeting with all suppliers

Regarding additional process of survey supportability to suppliers before releasing actual firm order to suppliers, the project team needed to set a meeting with all suppliers. The purpose of the meeting was to present and explain new ordering process in order to have the same understanding with all suppliers. Also, ABC Company focused on the necessary information that needed supplier's feedback as well as the time that suppliers needed to confirm back because of the time constraint of ordering system.

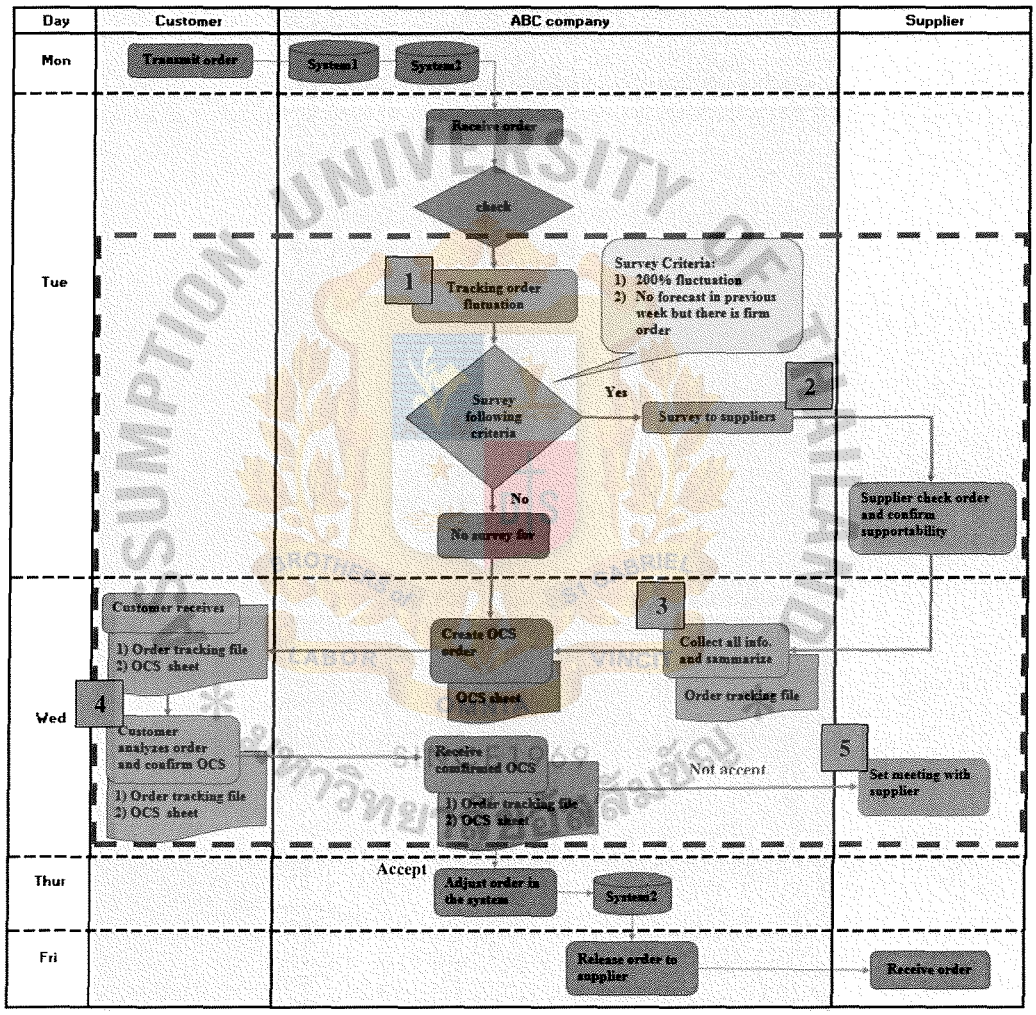
4.1.3 Design new process

The order fluctuation problem occurred from customer side and the current ordering process lacks of tracking order fluctuation process. Hence, the project team designed new process by adding the tracking order fluctuation process and survey supportability of suppliers for firm order volume on same day that ABC Company receives the firm order.

Figure 4.1 shows To-be process which is the new designed process of ordering. There are five main processes added (1) Tracking order fluctuation process, (2) Survey supportability to suppliers, (3) ABC Company summarizes information (4) Customer

analyzes order tracking file and (5) Set meeting with supplier to increase supply capability.

Figure 4.1: To-be Process



Source: Author

4.1.3.1 Tracking order fluctuation process

This process is mainly handled by Part ordering team (PO). After the order has been input into system by customers, PO team uses order volume in the system to analyze the order fluctuation every Tuesday morning. The PO team makes comparison between firm order (N) and previous forecast (N-1) to see how much change has occurred in each item.

This process is advantageous to increase awareness of ordering volume and trend for PO team. Moreover, the warehouse team can use the ordering volume information to manage and prepare manpower in warehouse, booking container space, and packing materials effectively and precisely. After tracking the order fluctuation, the PO team sends information to supplier to survey supportability to suppliers.

4.1.3.2 Survey supportability to suppliers

After the PO team has completely analyzed the order, the PO team surveys the order fluctuation to suppliers every Tuesday morning. The PO team will survey only items which match with the criteria. There are two criteria for the survey to suppliers. First criterion is the order fluctuation which has to be more than 200% by comparing firm order (N) and previous forecast (N-1). This criterion selects order fluctuation 200% because order fluctuation 100% is additional order only one lot which most of suppliers can support those additional volume. Second criterion is no forecast provided in the previous week (N-1) but there was firm order (N).

For survey supportability to suppliers, it is the same day that ABC receives order, so suppliers also have updated information same as ABC Company. After the suppliers receive the survey, they need to review and check the firm order volume then confirm the supportable firm order back to PO team. For suppliers who cannot support all firm order volume, they have to inform the estimated recovery plan of the remaining volume as well. Suppliers have to feedback to the PO team within Tuesday because on Wednesday, the summarized information has to be sent to the customers.

This process is beneficial to suppliers in order to increase supplier's awareness and increase time for checking capacity machine, manpower, material, finished goods part, and other resources. After the PO team receives information from suppliers, information will be summarized.

4.1.3.3 ABC Company summarizes information

After the suppliers confirm the supportable volume and recovery plan, the PO team will collect and summarize all information in the order tracking file on Wednesday morning. Figure 4.2 shows the order tracking file which consists of the order fluctuation information, the supportable volume, and the recovery plan from suppliers.

The remaining firm order volume that the supplier cannot support will be added in the OCS sheet for order cancellation request. The order that is requested to be cancelled would be requested customers to add back following the supplier's recovery plan confirmation. After that, the PO team sends order tracking file and OCS to customers for analyzing in next process.

As ABC Company summarizes information from supplier's feedback, the company will have the information about possible parts that could be critical parts in the future.

Figure 4.2: Order Tracking File

ABC company											Suplier confirm ontime							
BUYER	PART NO	PART NAME	SUPPLIER	MAKER	DEPO	SNP	WKXX (TH) Vanning				Supplier confirm supportable volume		Final confirm cancel order	Recovery plan from supplier (Remain Order)				
							Firm order	Previous forecast	Fluctuation	Fluctuation %								
							N	N-1	DIFF QTY	DIFF% (Adjust)	Suplier confirm ontime	Remain order	Cut order (Roundup to SNP)	Recovery QTY1	Recovery Date1	Recovery QTY2	Recovery Date2	Total Recovery plan

Source: Adapted from Company's data

4.1.3.4 Customer analyzes order tracking file

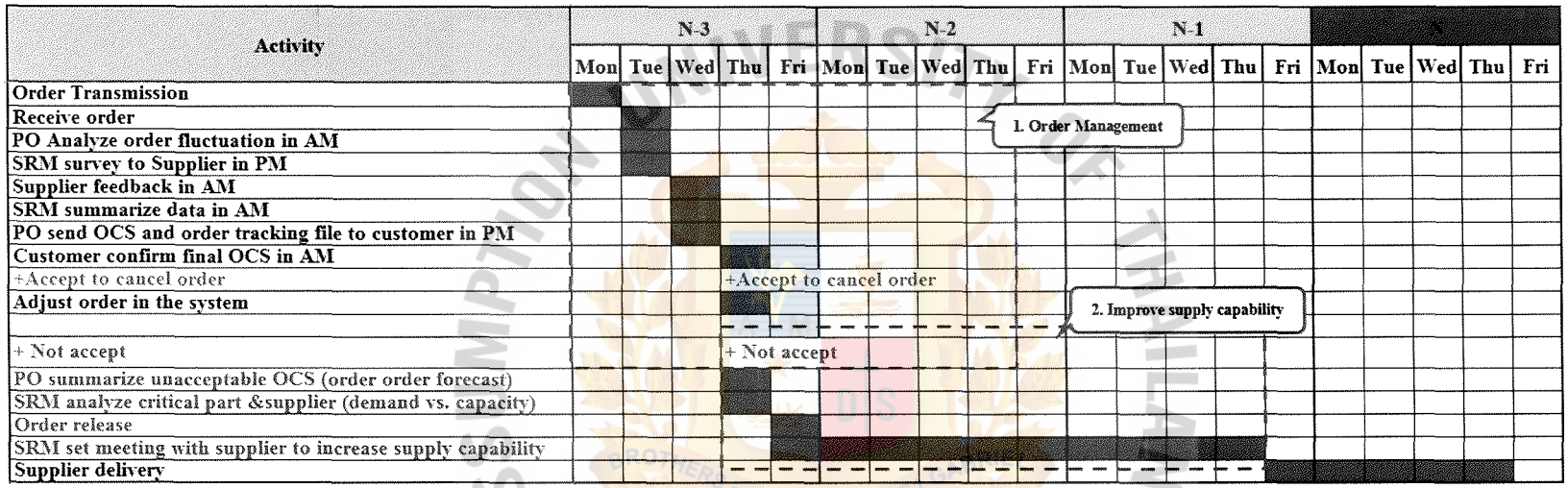
In this process, customers need to use information in order tracking file to analyze and check with their production plan whether they can accept the recovery plan volume from suppliers or not. After the customers have completely checked, they have to confirm their feedback in order tracking file and OCS sheet and send it back to PO team within Wednesday. Then, the PO team adjusts firm order following OCS sheet on Thursday and release the order to supplier on Friday. Then, suppliers receive the actual firm order on Friday.

4.1.3.5 Set meeting with suppliers to increase supply capability.

Figure 4.3 shows the milestone of ongoing activities. There are ongoing activities after the actual order is released to suppliers. For the item that customers cannot accept the recovery plan from suppliers, the Supply Risk Management team (SRM) needs to set a meeting with suppliers to increase supply capability based on customer's feedback. SRM team needs to discuss with the suppliers for the next action to expedite raw material in supplier's pipeline, air freight raw materials from overseas, adding over time for production or other possible actions to increase more supply.

Once SRM team has completely discussed with the suppliers, they will summarize the possible solutions and send to PO team. Next step is PO team will discuss with the customers which solutions need to be selected.

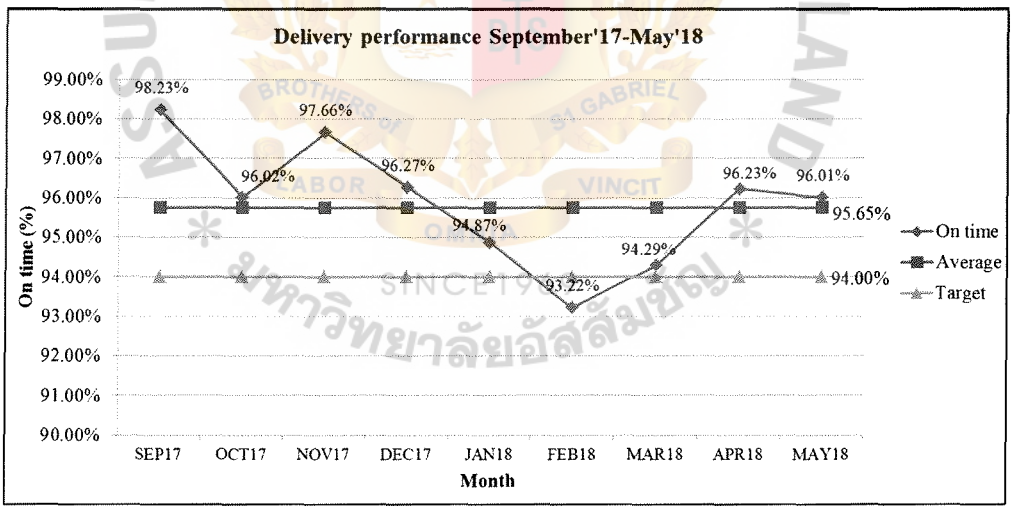
Figure 4.3: Milestone of Activities



Source: Author

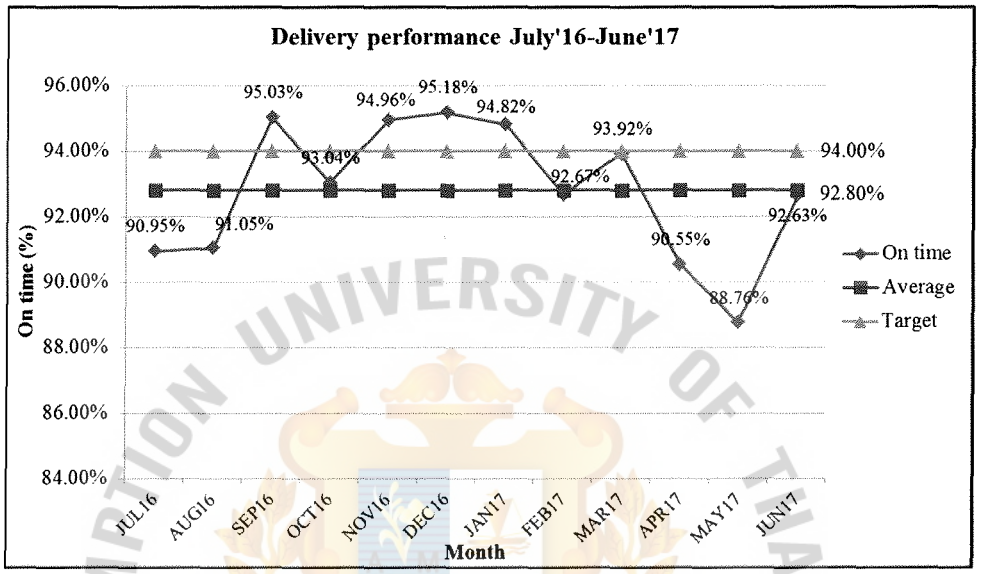
After the new process has been designed and announced to all related parties, such internal team, customers and suppliers, ABC Company starts to implement the new process. The monitoring period was during September 2017 to March 2018 because of time limitation. The improvement action was done in September 2017. The researcher used control chart to monitor the delivery performance of suppliers. Figure 4.4 displays supplier's delivery performance during September 2017 to May 2018 after the new improved process was implemented. The average result of delivery performance during September 2017 to May 2018 was 95.65%, which could achieve KPI target. Moreover, the average delivery performance after implementing the improved process was better than before implementing the improved process (95.65% > 92.80%), which is shown in Figure 4.5.

Figure 4.4: Delivery Performance during September'17-May'18 After implementing the improved process



Source: Adapted from Company's data

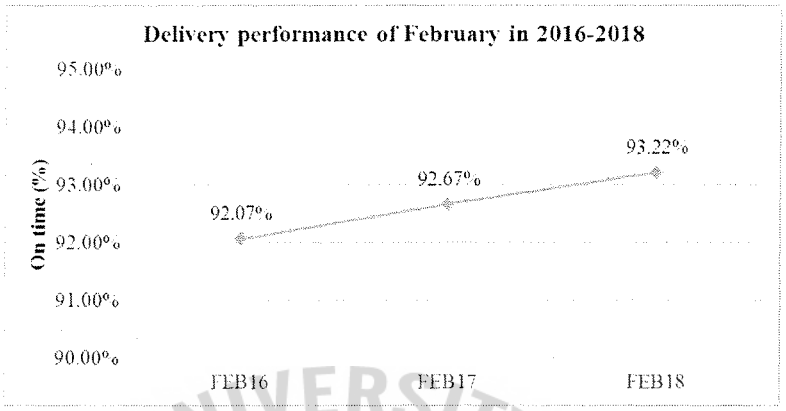
Figure 4.5: Delivery Performance during July'16-June'17
Before implementing the improved process



Source: Adapted from Company's data

However, the delivery performance in February 2018 was under target of on-time delivery. This was because the order in February, most customers increased their order to add up to their production for fiscal year ending in March 2018. Also, there is a record of the delivery in the past year, which is shown in Figure 4.6. The delivery performance in February of each year is not quite good, but in February 2018, it was better than the past 92.07% in 2016, 92.67% in 2017 and 93.22% in 2018 respectively.

Figure 4.6: Delivery Performance of February in 2016-2018



Source: Adapted from Company's data

In addition, there was an unexpected situation. The warehouse of supplier got fire in February 2018, which caused delayed delivery. The delay due to the burned supplier's warehouse was solved in March 2018. Moreover, February is a seasonal event that customers always increase their order because of more production plan in March to support the fiscal year end and to try reaching the production target. However, after the project team became aware and knew this special condition, they discussed with PO and SRM team to concentrate more and focus on the month of February for increasing in order and communication with suppliers. In summary to the implementation of the improved process and more concentration in February, the delivery performance in February 2018 is better than the past year.

After the new designed process and several activities were implemented, the four major root causes were improved. Table 4.1 shows the results after improvement during the improved process which was implemented during September 2017 to March 2018. The average results of four major root causes, such as order over forecast (44.88%), capacity machine (7.91%), capacity manpower (3.93%), and material and finished goods shortage (4.30%) were improved significantly.

Table 4.1: Average Result after Improvement

Year	2017				2018			Jun'16-Jul'17	Sep'17-Mar'18	
The root cause	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Average Before Improvement	Average After Improvement	Gap (After-Before)
Order over forecast	44.10%	45.12%	44.70%	42.34%	42.12%	50.15%	45.64%	47.95%	44.88%	**-3.07%**
Capacity machine	7.46%	8.56%	7.33%	8.33%	8.22%	10.85%	4.65%	11.17%	7.91%	**-3.26%**
Capacity manpower	6.34%	5.94%	0.92%	0.53%	6.51%	1.68%	5.62%	7.24%	3.93%	**-3.30%**
Material and FG shortage	5.69%	4.67%	3.89%	2.01%	5.12%	3.06%	5.62%	5.82%	4.30%	**-1.53%**
Plan not Balance	0.11%	0.49%	7.53%	8.77%	2.66%	4.65%	6.92%	5.76%	4.45%	-1.32%
Order over capacity	0.43%	8.96%	7.88%	7.70%	7.10%	6.14%	10.83%	5.47%	7.01%	1.54%
Human error	3.01%	2.32%	3.14%	2.12%	2.28%	1.79%	1.13%	4.41%	2.25%	-2.16%
Machine breakdown	13.64%	6.51%	8.31%	8.44%	9.05%	5.03%	2.63%	4.38%	7.66%	3.27%
Quality	9.93%	7.22%	11.07%	14.23%	11.03%	5.21%	7.70%	2.62%	9.48%	6.86%
Transportation delay	2.79%	1.83%	1.64%	1.54%	1.49%	1.91%	0.93%	1.84%	1.73%	-0.11%
Unpacking	2.94%	6.07%	1.90%	1.24%	2.05%	2.03%	2.32%	1.30%	2.65%	1.35%
New model	3.13%	2.14%	1.57%	2.51%	1.34%	1.38%	1.45%	1.11%	1.93%	0.82%
3PL mistake	0.43%	0.18%	0.13%	0.24%	1.03%	0.18%	0.94%	0.91%	0.45%	-0.46%
Warehouse fire	0.00%	0.00%	0.00%	0.00%	0.00%	5.95%	3.62%	0.00%	1.37%	1.37%
Total	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	

Note: Average before the improvement was calculated during June 2016 to July 2017

Source: Adapted from Company's data

4.2 Control phase

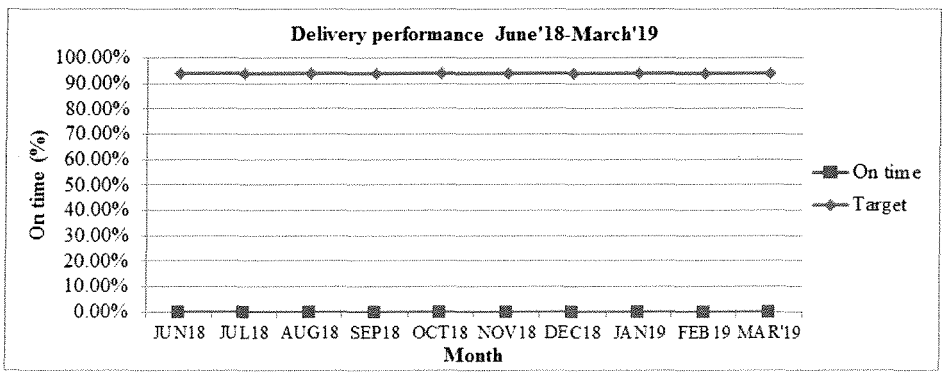
After finding the solutions and implementing several actions to solve the problem in improve phase, next is control phase which is the last phase of DMAIC to sustain the improved process and operation as well as to control long term plan for sustainability. Moreover, monitoring the improvements of supplier's delivery performance and achieve KPI are needed to be done. Control plan consists of three main things (1) Control chart, (2) Weekly report and weekly meeting, and (3) Monthly review and suppliers' training.

4.2.1 Control chart

The company uses control chart which shows in Figure 4.7 to monitor the delivery performance time over time. The result is monitored by the manager of the PO team. This monitoring is done continuously by the PO team to ensure that supplier's delivery performance is closely monitored and that the delivery problem from suppliers or other problems would be solved immediately when it occurs.

Figure 4.7: Control Chart for Monitoring Delivery Performance

	Delivery Performance during June'18 to March'19										
Month	JUN18	JUL18	AUG18	SEP18	OCT18	NOV18	DEC18	JAN19	FEB19	MAR'19	Average
Target	94.00%	94.00%	94.00%	94.00%	94.00%	94.00%	94.00%	94.00%	94.00%	94.00%	94.00%
On time											



Source: Adapted from Company's data

4.2.2 Weekly report and weekly meeting

The company sets a weekly report to analyze the root causes along with monitoring delivery performance by control chart. Moreover, weekly meeting among cross-functional team is set to review and discuss about delivery results and existing problems at that period. The related teams, such PO team, SRM team, and warehouse team are required to attend the meeting. This meeting is done continuously to ensure that the problem will be raised in the meeting and the right team will take action to solve the problem immediately.

4.2.3 Monthly review and suppliers' training

As the company already has monthly meeting with the suppliers, so the company will review and conduct a monthly training for the suppliers for the ordering process in order to refresh the process with the suppliers. Also, this solution helps to ensure that suppliers will understand the ordering process between ABC Company and suppliers. In addition, this solution is to ensure that suppliers take action for activities of ordering process correctly and effectively.

4.3 Chapter Summary

This chapter focuses on the improve phase and control phase of DMAIC approach to solve the problem on delayed delivery from suppliers. The improve phase has three main activities to be done which are to design new process, set meeting with all customers, and set meeting with all suppliers. After implementing the improvement plan, ABC Company needs to control the process to ensure that the improvements are sustained and the ongoing performance is well monitored.

CHAPTER V

SUMMARY FINDINGS, CONCLUSIONS AND RECOMMENDATIONS

This research is focused on solving the problem of delayed delivery from suppliers of ABC Company. This research applied the DMAIC method to find the root causes of the problem and develop effective solutions. Therefore, this chapter presents the discussion of findings, summary, conclusions, theoretical implications, managerial implications, limitations and recommendations for future research.

5.1 Summary of the Findings

The purpose of this research was to improve delayed delivery from suppliers of ABC Company. The problem which directly affected KPI of on-time delivery from suppliers was lower than KPI target of 94% on-time delivery and customer satisfaction. The researcher reviewed the related literature and identified that DMAIC was an appropriate model. DMAIC was used to identify the root causes of the problem, mitigate or solve the problems and proposed sustainable solutions to solve the problem of ABC Company in long term.

After that, the researcher collected necessary information and applied Pareto analysis to find out the highest impact 80% from 13 root causes of the problem to reveal the biggest impact. The researcher analyzed further which of the root causes was possible to be solved and improved. The four major root causes, such as order over forecast, capacity machine, capacity manpower, and material and finished goods shortage were selected to improve. These four major root causes had been studied further by analyzing the as-is process. Then the researcher identified the areas for improvement to design the improved process. In Improve phase, the researcher used new improved process and data collection of the order volume to analyze. Then the significant change in order has to be informed to suppliers in advance and improve supply capability with suppliers. The improved process would result in sustainable improvement of reducing delayed

delivery from suppliers. Ultimately, in control phase, the researcher used the control chart to closely monitor the delivery performance. Moreover, weekly report and weekly meeting were used to update the status of delivery situation and problem. Also, monthly training for suppliers was created and implemented to ensure that the performance would sustain in good direction.

The significant results of using the DMAIC concept were to achieve the 95.65% of on-time delivery performance from suppliers. Moreover, it helped to improve the major root causes and increase awareness of ordering trend to both ABC Company and suppliers. Finally, the current process has been improved to capture the missing process and add necessary process in to-be process.

5.2 Conclusions

The DMAIC concept is a guideline and helps to understand how to solve the problem effectively and properly. It helps the company to achieve KPI of on-time delivery from suppliers and improve or mitigate the impacts from several root causes.

Applying the DMAIC concept helped the problem more visible to the cross-functional team. In addition, it also helped the team understand the root causes of the problem better and could use the potential tools to create possible solutions to solve the problem. Moreover, new designed process helped the company improved and added necessary processes and increased the awareness of ordering trend among customers, ABC Company, and suppliers. Finally, continuous improvement and monitoring of the operational process would help the team capture the situation of order and supplier's performance as well as to sustain the on-time delivery in good performance.

5.3 Theoretical Implications

This case study used DMAIC model, which consists of defining the problem; measuring the problem by using the actual data and facts; analyzing the root causes of the problem; improving the current process; and controlling to ensure sustained improvements. According to Karout and Awasthi (2017), DMAIC is an effective problem solving and systematic method for eliminating unnecessary processes or errors and improving efficiency. Each phase of DMAIC includes a set of tools which represents Kaizen or continuous improvement (McCarty et al., 2005).

This research applied the DMAIC model to improve the existing problem and sustain corrective solutions for delayed delivery from suppliers. The researcher found that the improved process required high collaboration among ABC Company, customers, and suppliers in order to achieve the company's goal. Moreover, DMAIC helped to solve delayed delivery from suppliers as well as it helped to improve the delivery performance from ABC Company to overseas customers. In addition, it helped to analyze and improve problems of current ordering process and develop new designed process of ordering process to be more effective.

Pareto analysis helped the researcher to prioritize and represent root causes of the problem under consideration in ranking orders (Cervone, 2009). Value added analysis was used to standardize the process by identifying and eliminating variation in the process and create value of each process step from the customer's perspective (Shaffie & Shahbazi, 2012). Meanwhile, process map was used to represent the linkage each process (De Feo, 2017). Brainstorming was used to stimulate group of people for new ideas generation (Levine et al., 2015). Lastly, run chart was used to monitor and track the change in performance over time in the process improvement (Shaffie & Shabazi, 2012). Overall, the improvement should be sustained in long run.

5.4 Managerial Implications

This study can help ABC Company to find the root causes of delayed delivery from suppliers and solve the problems by using the DMAIC method. Moreover, the company can find solutions to prevent and improve the existing root causes, such order over forecast, capacity machine, capacity manpower, and material and finished goods shortage.

DMAIC helped the company to have more understanding of current process of ordering. DMAIC was used to improve and develop several internal processes of ABC Company to be more effective and appropriate. This study also involved developing several activities for improving delayed delivery from suppliers. The new designed process of ordering has been created by adding necessary missing processes as well as communication improvement among related parties among ABC Company, customers and suppliers.

In define phase used process map to analyze the existing problem. In measure phase used data collection to collect necessary information to analyze the problem in next step. In analyze phase used the collected information, process map with Value added analysis and Pareto analysis to analyze the root causes of problem. In improve phase used new designed process flow to address the existing problem. Finally, in control phase used run chart to track and monitor delivery performance from supplier after new designed process has been implemented.

Tools such as Pareto analysis and process map with values analysis were used to indicate the main area of the problem and the root causes for those problems based on data analysis. Brainstorming was used in group discussion in the project team in order to generate ideas for process improvement and solving existing problem. Run chart was used to control and monitor delivery performance from supplier after new designed process was implemented. Finally, ABC Company can reduce delayed delivery from suppliers and achieve KPI target, preventing recurrent problems, and increase customer satisfaction at the same time.

5.5 Limitations and Recommendations for Future Research

This case study was conducted to identify the root causes of delayed delivery from suppliers of the Japanese car manufacturing company by using the DMAIC method. This research has limitations. First, the researcher focused on ABC Company only because of the availability of information and time constraint. Secondly, the researcher analyzed the root causes of delayed information from suppliers of ABC Company by using the historical data during July 2016 to June 2017. Finally, the researcher implemented an improvement plan with customers of ABC Company during September 2017 to March 2018 and summarized the result around April 2018 because of time constraint.

According to the study, the focus is on delayed delivery from suppliers of the Japanese car manufacturing company by using the DMAIC method. It is highly recommended to use this study as a guideline and apply to other businesses facing with similar problem like ABC Company. Moreover, the company can use the DMAIC concept to apply and solve the problem in other areas of business processes, not only in the delayed delivery problem from suppliers.

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