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A CASE STUDY ON USING THE DMAIC METHOD TO INNOVATE LOGISTICS PROCESS

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Abstract

The present research takes the logistics sector of a Taiwanese company as an example and employs the six-sigma DMAIC method (i.e. a five-phase method composed of defining, measuring, analyzing, improving, and controlling) to upgrade the company's logistical management. This research focuses on optimizing the company's logistical processes and aims to shorten its transportation time and increase its loading efficiency. The enhanced logistical processes empowered the overall dispatch system of this company to save much manpower and time by adopting a real-time vehicle monitoring system, and thus reduce the errors of vehicle dispatching; in addition, it can perform the fastest vehicle scheduling within a short time. Moreover, applying this systematic management method to vehicle dispatch management has significantly enhanced the current monthly average dispatch rate as well as improved the company's logistical performance in several aspects such as monthly average transportation distance per person, shipping times, and shipping weight.

Keywords: six sigma, DMAIC method, logistics

Introduction

In order to enhance their competitive advantages, most companies have implemented modern management concepts to improve their organizational efficiencies and cost-effectiveness, as well as strengthen their economic and technological capabilities. This research presents a case study of the logistics sector of Company M, which adopted the DMAIC management method to optimize its logistical processes. The research feedback and analysis results were provided to guide this company for improvement. The research objectives

are shown below:

1. Perform a case study of the logistics sector in Company M so as to explore the company's internal organization, the overall operation situations, transportation processes, and its existing problems.

2. Explore the literature relevant with six-sigma DMAIC methodology in order to identify the key successful elements which can provide references for this research, establish the research architecture, and further improve the transportation processes.

3. Adopt the six-sigma DMAIC methodology and its five major cycles to improve logistical performance after discussing with relevant staff to provide suggestions for process optimization.

The research structure is divided as follows: Section 1 describes the research background, motivation and objectives. Section 2 presents literature review, and explores the topics such as six sigma, DMAIC steps, and logistic issues. Section 3 illustrates the research methods, steps, and develops a framework for introducing a six- sigma method. Section 4 adopts the proposed framework to conduct case analysis. Section 5 summarizes conclusions based on the research results and provides suggestions for future research.

Literature Review

This section illustrates and explores the literature related to six sigma, DMAIC steps, and logistic issues. With the adoption of six sigma approaches, numerous companies were able to outperform their pervious outcomes by growing and gaining profits significantly within a short period of time. Subsequently, the six sigma approaches has attracted much attention from a great deal of enterprises and become the most important issues regarding quality control in the 21st century (Pande & Holpp, 2002). When implementing the six sigma approaches, each company should choose to leverage different processes with considerations of its own needs and characteristics. Generally speaking, there are three different options for this transition process: (1) entrepreneurial transformation, (2) strategic improvements, and (3) problem-solving. The selected transition process will determine the affected extent and range of companies and their employees (Pande & Holpp, 2002).

According to Sokovic et al. (2010), DMAIC is a systematic and fact-based method which provides a results- oriented framework for project management, and it has been widely adopted across several industries. Abdur et al. (2018) applied the six-sigma DMAIC methods to investigating the product defect issues in the garment industry. Their study showed the garments defects were reduced by 35% after the adoption of six-sigma DMAIC methods, and its sigma level has upgraded from 1.7 to 3.4. Based on Leaphart et al. (2012), the incorporation of DMAIC methods into formal quality improvement curriculum can facilitate interdisciplinary collaboration and enable process improvement for renal transplant patients. Antony et al. (2012) explored the application of six-sigma DMAIC approaches in terms of communication and information management. As presented by Cunha & Dominguez (2015), a large Portuguese car dealer implemented the six-sigma DMAIC stages and obtained successful

results, showing that these new metrics may be applicable for all the car dealers who provide warranty services.

Pande and Holpp (2002) indicated the three strategies for six-sigma methods: (1) process improvement, (2) process design/redesign, and (3) process management. As shown by Sin et al. (2015), knowledge will exercise positive effects on the success for six-sigma projects, and further enhance companies' performance. Kumar et al. (2009) pointed out the six-sigma DMAIC process is an effective and innovative approach which can be applied to the machinery industry and manufacturing industry and it can improve companies' profitability by reducing manufacturing costs.

Lee's (2005) study proposed to adopt six-sigma methods to revolutionize all the internal processes and the overall supply chain system of companies, and to increase the cost-efficiency of operational processes in order to drive higher production capacity and competitive advantages continuously. The six-sigma DMAIC methods are considered problem-solving solutions which can maintain company revenues (Snee, 2004), and the DMAIC steps are presented as Figure 1.

Source: Snee (2004)

Figure1. The structure for DMAIC workflow

As pointed out by Pelton et al. (1997), "logistics" is a systematic process which involves products/services delivery to attain cost-efficiency and operational efficiency. The contemporary logistic industry is characterized with multi-features, systematization, globalization, informationization, and standardization. The fundamental goal of developing a modernized logistic system is to take control of accurate time and locations so that the right products with right quality can be delivered to the right customers. Thus, the distinction between the past and modern logistic systems is the latter focuses on achieving the organizations' overall efficiencies and profits, and systematizes all the logistic features (Wang et al., 2001). Chalmeta and Grangel (2001) believed that system integrations can bring the following benefits which enable companies to make comprehensive decisions: (1) provide strategic advantages for enterprises, (2) offer quantifiable profits, and (3) have clear control over the delivery time of products, inventory cost of raw materials, and direct/indirect labor cost.

Research Method

The six-sigma method primarily aims to optimize processes so the department heads can better manage their business. This method can be used to identify the issues of the processes and improve the processes to reduce unnecessary waste. DMAIC is the most commonly used method among all the six-sigma techniques. It is also a standard operating procedure with a rigorous structure that can solve problems and achieve consistent goals.

Research Steps

This research takes a reference to the six-sigma DMAIC steps to understand the internal structure, overall operation status, transportation processes, and existing problems of the logistics sector in Company M. Afterward, the analysis results and feedback for improvement were provided to assist Company M to obtain substantial help. This section describes the research structure, steps, and methods as follows:

1. Explore the internal arrangements, overall operation situations, transportation processes and existing problems of the logistics department from Company M.
2. Formulate a basic structure to understand the key factors to improve transportation processes.
3. After discussing with Company M's internal employees or supervisors, the six-sigma DMAIC method is adopted in order to propose suggestions to optimize the transportation processes.

Research Design

According to Harry and Schroeder (2000), DMAIC is a structured and rigorous method, which can be applied to address business problems and to achieve business goals. This research aims to optimize logistical processes, and the tools available for performing six-sigma analyses are very extensive. The following Table 1. shows the auxiliary tools that can be used in different stages.

Table 1. Tools available for six-sigma analysis

Phase	Available Tools
Define	Flow chart, statistical analysis, quality function deployment (QFD), risk assessment, financial analysis
Measure	Pareto chart, cause & effects chart (or fishbone diagram), Gage R&R, process capability analysis
Analyze	Assumption verification, scatter diagram, benchmark learning, correlation/regression analysis, process capability analysis (Cp & Cpk), characteristic factor diagram, verification analysis
Improve	Sampling size, design of experiment (DOE), risk assessment, measurement system evaluation (MSE)
Control	SPC statistical process control, checklist, failure mode and effects analysis (FMEA)

Source: Harry and Schroeder (2000)

Implementation Items

This research adopted the six-sigma DMAIC method to upgrade the operational quality and logistical processes by executing its five action steps. The application steps and available tools for the five-phase process are listed in Table 2.

Case Analysis

This section is divided into seven steps. Step 1 presents the introduction and the problems description of the case company. From Step 2 to Step 6, the implementation process of the DMAIC methods is illustrated. In the end, Step 7 displays the overall performance of the investigated company.

Description of the Case Company

The logistic sector in the case company has played a critical role for delivery processes, and the whole workflow includes a series of meticulous operational procedures, which involve loading, unloading, and shipping raw materials, as well as delivering finished products to customers. Besides, the logistic sector also needs to handle the potential risks which may occur during the delivery process. Only when these logistic processes are optimized with the guidance provided by the logistic manager and team, can the whole team achieve its ultimate business goals and gain more profits by reducing its delivery cost and driving real values.

Table 2. The steps and tools of DMAIC method

Phase	Steps	Available Tools
Define	*understand customers' needs *Recruit a project team *Define the process with a flowchart	Six sigma, balanced scorecard, SIPOC, ERP
Measure	*Collect project information *Develop a project plan *Measure the project process	Pareto chart, Gantt chart, trend chart
Analyze	*Analyze data *Draw up an improvement plan *Prioritize the improvement items	Pareto chart, histogram, fishbone diagram
Improve	*Propose an improvement plan *Develop an improvement plan * Eliminate potential factors	Hypothesis testing, design of experiment (DOE), risk assessment
Control	*Execute improvement plan *Audit process regularly *Update the control plan table and project closure report	Standard operating procedure (SOP), statistical process control (SPC), checklist

The logistical issues are summarized as follows: During the period from January to December 2018, the case company has often been confronted with the insufficiency problem of available shipping vehicles. After the internal review, immediate improvements should be made to avoid the occurrence of major losses or breach of contract caused by operation.

Define the Delivery Problem

In this study, the current shift arrangements are based on the rule of thumb. This type of arrangements only aims to deliver goods to the destination, but it does not take the problems of scheduling and vehicle arrangement into consideration, which confines the case company within its obsolete thinking mode. After review, this study adopted the DMAIC method to schedule preceding tasks for the case company and to establish appropriate procedures to improve work efficiency. In addition, after the introduction of the new logistics concept, the SIPOC mode, the current overall transportation process is more complete, as shown in Figure 2 below.

Figure 2. The case company adopted the SIPOC and DMAIC methods

Measure KPI

After review, the company should prioritize maximizing the transport efficiency of vehicles when dispatching vehicles. Before departure, it is necessary to investigate the driving route in advance, and then determine the locations along the way, the number of vehicles that need to be assigned, the starting and ending points of the driving route, the time of driving and loading goods, etc. Regarding the arrangement of drivers and vehicles, relevant key performance indicators (KPIs) need to be established to show the effectiveness of the improvement, as shown in the following Table 3.

Table 3. The KPI table of dispatching arrangement

Aspect	KPI	Calculation
Shipping efficiency	Average monthly shipping distance per driver	Total transport distance/number of personnel
	Average monthly times of driving per driver	Total number of transported vehicles/number of personnel
	Average monthly delivery weight per vehicle (/truck)	Total transport weight/total number of vehicles (trucks)

Identify the Root Cause

Regarding the factors that may influence dispatching arrangement, the amount of cargo and the load capacity per driver will reflect the transportation demand issued by the requested sector. For the logistics sector, the internal controllable factors include the number of dispatched vehicles, driving routes, and the carrying capacity of vehicles. The external factors involve the vehicle availability provided by the logistics sector. In addition, the uncontrollable transportation factors will affect vehicles' driving speed and when can the vehicles be used for the next drive (See Figure 3).

Figure 3. Fishbone diagram of factors affecting scheduling

Solve problems

The factors that influence vehicle dispatching will pose risks on business operations. The potential risks can be divided into several dimensions, such as quality, cost, and delivery time. This research identified the potential risks of products and assessed the occurrence frequency and impact level (the score ranges from 1-10). The score between 6 and 9 indicates high risks, and the overall logistical process should be redesigned. These high-risk issues will be prioritized. The score between 2 to 4 represents medium risks. If the score is 1, it stands for low risk and usually does not need to be controlled and tracked. This study listed the potential risks for assessment in the following Table 4.

Table 4. The evaluation table for potential risks

Potential risk	Risk rating (1-10) (High/Medium/Low)			Consequence	Alternative plan
	Frequency	Impact factor	Total score		
Insufficient dispatched vehicles	3	3	9	Default loss	Build a vehicle monitoring system
Change of driving routes	1	3	3	Delivery delay	Import real-time traffic system
Insufficient vehicle capacity	1	2	2	Increased costs	Develop equipment investment plan

In the past, the research on vehicle dispatching and scheduling primarily focused on the arrangements under normal conditions, so it cannot effectively respond to emergencies. This research adopted the real-time vehicle monitoring system as the basis in order to understand the dispatching situations when dealing with emergencies as well as consider the route and provide support from the overall point of view (See Figure 4).

Implement the Control System

In order to simplify the application of the dispatching system and get rid of manual scheduling as much as possible to save manpower and time, this research exactly implemented a control management system. In this way, errors in vehicle arrangements can be reduced, and emergencies can be immediately dealt with in a short period of time. Several operation issues (such as personnel ask for leave and unknown vehicle movement) will cause the original schedule to change. With the implementation of real-time monitoring control system, all these issues can be handled step by step, as shown in Figure 5.

Figure 4. The main usage of real-time vehicle monitoring system

Figure 5 The priority workflow of personnel arrangement

When emergencies happen, multiple shifts may need to be adjusted. However, the dispatching adjustment to each shift must be considered one after one. After adopting the first scheduling strategy, the adjusted shifts will be included in the original shift schedule. If the previous dispatching strategy cannot solve the current situation, the next strategy will be adopted until all the necessary adjustments are made (See Figure 6).

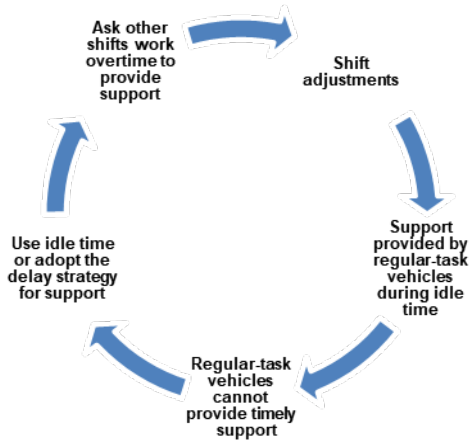

Figure 6. The workflow for shift adjustments

Work effectiveness

The study found that the difficulties of vehicle arrangement faced by the case company are caused by their

inability to effectively control the overall information of vehicles on the road. Therefore, the company adopted the real-time vehicle monitoring system to track the location of the vehicle in real-time. By comparing the vehicle dispatching performance of the case company from 2018 to April 2019, it is shown the monthly average unavailability rate of vehicles decreases from 6.16% to 1.75%. Additionally, this study performs assessments based on the overall transportation efficiency. As indicated by the monthly average transportation distance per person, the monthly average shipping times per person, and the monthly average shipping weight, it is shown decent results, particularly in the aspect of shipping times per person. The comparison table is shown below (Table 5).

Conclusions and Suggestions

In this study, a project team was established to identify the key factors for optimizing transportation process, and the six-sigma DMAIC method was adopted to make improvements. This research also probes into the transportation scheduling process, with the goal of shortening the transportation time and improving the loading efficiency. In addition, this research uses a case study method to verify the proposed model. To minimize the manpower and time invested in the overall dispatching system, the vehicle dispatching errors can be significantly reduced after introducing the real-time vehicle monitoring system. Moreover, the optimized system can quickly deal with emergency tasks within a short time, resolve the problems of vehicle dispatch management, and achieve the following results.

Table 5. KPI results for dispatching vehicle

Factor	Indicator	Work effectiveness		
Transport efficiency	The monthly average transportation distance per person	2018 (annual average)	2019 Q1-Q4 (monthly average)	Increment
		2532 (km)	2658 (km)	4.9%
	The monthly average shipping times per person	2018 (annual average)	2019 Q1-Q4 (monthly average)	Increment
		13.9 (times)	19.6 (times)	41%
	The monthly average shipping weight of	2018 (annual average)	2019 Q1-Q4 (monthly average)	Increment

	each vehicle (Truck)	777.6 (tons)	831.8 (tons)	6.9%
Note	The shipping weight of 10.5T-truck will be counted as 9T (the average safety weight).			

1. The monthly average unavailability rate of vehicles decreases from 6.16% to 1.75%.

2. The monthly average transportation distance per person increases from 2532 (km) to 2658 (km).

3. The monthly average shipping times per person increases from 13.9 (times) to 19.6 (times).

4. The monthly average shipping weight of each vehicle increases from 777.6 tons to 831.8 tons.

There are still some areas for improvement in this research, and the suggestions are provided as follows:

1. The current model proposed in this study requires the assistance of experts. If future research can formulate detailed standard operating procedures, this model can be used as a reference for other companies.

2. This research only analyzes and discusses how to improve the transportation processes. It is suggested that future research can conduct a more detailed and in-depth analysis of data collection, transportation routes, cargo types, loaded capacity, and integrated information operating systems.

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