Optimization of delivery for an e-commerce industry using Six Sigma methodology

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Abstract

A timely delivery is a basic requirement of customer these days and becomes an annoying parameter for them if unfulfilled. The purpose of this paper is to present a case study of an e-commerce industry which was struggling towards the timely delivery for their premium subscription customers. A systematic approach of Six Sigma methodology was used to optimize the scenario. This paper showcases the detailed review and analysis of the problems faced by the e-commerce industry using various six sigma tools and techniques including design of experiments. During the project, more than 100 data points were studied and more than 800 data sets were analyzed initially to identify and further to analyze the problem. The paper also emphasizes the approach of problem solving using the six-sigma methodology for the practitioners as well as academic researchers.

Keywords: Six Sigma, Problem Solving, e-Commerce, Delivery, Design of Experiments

1.0 Introduction

Due to heightened rivalry, more demanding customers, and the frequently uncertain economic climate in many countries, the external environment that impacts organisations is constantly changing. Running operations at the lowest cost, with greater dependability and speed, and with a better ability to adapt and constantly improve are some of the pillars in the development of operations strategy in organisations that aim to flourish in this competitive environment.

E-commerce is one of the most important components of all businesses/industries because it enables them to contact more customers and give them more ease. By doing away with the requirement for real stores and sales personnel, it also enables an organisation to lower expenses and boost efficiency. In addition, it can be used in a manner to gather information about their clients, which will help them better understand their wants and preferences and design experiences that are tailored to them. Customers can buy products online, frequently swiftly and easily, with the additional convenience of free shipping and returns. It was created to help companies function more cost- and efficiently.

Any e-commerce company's main challenge is to comprehend customer expectations in order to assess the value of their e-commerce product based on how their customers view it and how it stacks up against those of other companies in the same sector and, ultimately, to increase their profits. However, in recent years, we have noticed that many businesses are having trouble maintaining their profits or that there is a general pattern of falling profits in these e-commerce businesses.

To assess the data, examine, and identify variables influencing the retention of profits in the organizations, we will use models like LSS in this study. Lean Six Sigma, also known as LSS, is a well-known method for process optimisation and waste elimination that combines Lean Manufacturing and Six Sigma. LSS is frequently used in the highest-performing companies and is most helpful for process development, according to Spector R. (2006). It began in a manufacturing environment and ultimately found its way to services. According to Ronald D. Snee, Lean six sigma is a well-structured theory-based system to improve performance, promote effective leadership, raise client satisfaction, and generate bottom-line outcomes. (2010).

This paper begins with a succinct overview of the literature on Lean Six Sigma evaluation, which is followed by a talk of an evaluation framework and technique. The paper's end lists additional managerial applications and study opportunities while also outlining some possible drawbacks of the approach.

2.0 Literature Review

Total quality management (TQM), the Deming principle, and statistical process control (SPC) served as the basis upon which Six Sigma was first introduced. In 1987, Six Sigma was brought to the industrial sector by Motorola Corporation. The Six Sigma technique was used at Motorola to create goods free of faults as well as to eradicate flaws throughout the entire company. The SPC, on which it is based, enables a decrease in errors of up to 3.4 parts per million opportunities. The opportunity is the probability that the stated necessary won't be fulfilled. The Six Sigma technique was born out of the Greek symbol sigma (s), which stands for the standard deviation in statistics and the variance in a procedure. (Harry and Schroeder, 2000; Pande et al., 2000; Eckes, 2001; Rathi et al., 2016).

Importantly, Motorola used the acronym MAIC, which stands for measure, analyze, optimize, and control in the Six Sigma approach, to create a "roadmap" and a remedy for the issue. This approach was used to address a variety of problems in order to avoid the need to develop fresh answers for every problem and product that cropped up. Management supported this approach with infrastructure in the form of funding, project selection, resources, and numerous other areas. (Snee and Hoerl, 2007). Six Sigma was used as a quality strategy for ongoing organizational development when it was first presented in 1987. But it was less effective due to an absence of directional assistance.

The business part of the newspaper had moved from the back pages to the front pages, according to General Electric (GE) CEO Jack Welch, who made this announcement in 1995. Welch believes that Six Sigma was the greatest initiative GE ever launched, and that it will continue to be their top priority moving forward. (Welch, 2001; Kumar et al., 2015). GE has contributed significantly to the growth of Six Sigma since many other companies started looking into it. The DMAIC process was formerly known as the MAIC process because there wasn't a set structure for describing the project. Later, General Electric became aware of this flaw and decided to add a "Define" step to the MAIC method to guarantee that initiatives got off to the right start.(Antony et al., 2012; Kaid et al., 2016). In order to examine both production and non-manufacturing processes, GE encouraged the use of Six Sigma in the healthcare, sales, financial, and other sectors. (Hoerl, 2002; Gamal Aboelmaged, 2010; Arumugam et al., 2013).

DMAIC is used to execute Six Sigma initiatives when the method is being researched, according to Andersson, Henrik, and Hkan (2006). DMAIC's main objective is to guide the Six Sigma model's implementation while taking into consideration each of its five basic parts. Based on Kumar and Sosnoski, the DMAIC stages and related quality instruments are displayed in (Table-1). (2009).

Table 1 DMAIC methodology

N°	Phase	Tools
1	D – Define	Pareto analysis; Project charter
2	M – Measure	Descriptive statistics; Process capability analysis
3	A – Analyse	Detailed process map; Fish-bone diagram
4	I – Improve	Experimentation; New process
5	C – Control	Statistical process control

Source: Kumar and Sosnoski (2009).

In terms of growing timeline, TPS is comparable to Six Sigma and forms the basis for Lean development. (Womack and Jones, 2002; Womack et al., 2007). This process was developed in 1930 to make cars that are completely waste-free, including non-value-added human motion. In 1988, Krafcik is attributed with coining the term "Lean Manufacturing." (George, 2002; MacInnes, 2002; Bhasin, 2013).

In contrast to Six Sigma, which was primarily focused on using statistical analysis on collected data to solve various problems, Lean was typically applied primarily in knowledge-based tasks by applying time-tested principles, such as reducing inventories, continuous processing as opposed to batch processing, line of sight, cell manufacturing, and push versus pull production system. (Snee and Hoerl, 2007; George and George, 2003). In lean production, reducing waste and non-value-added components is highly valued. Lean manufacturing has found seven waste elements: defects, motion, overprocessing, overproduction, and stockpiles. Underusing human creativity and environmental loss are two additional wastes. (Vinodh et al., 2011; Wong et al., 2014). The kanban system, 5S, cause and effect analysis, value stream mapping, and many other tools and techniques are all part of the lean methodology. (Drohomeretski et al., 2014; Chen and Lyu, 2009; Thomas et al., 2008). The need for societal change, according to Womack and Jones (2005), poses a major obstacle to the adoption of lean because it demands a basic shift in the players' points of view and the dynamics of their interactions.

Six Sigma was developed by combining lean, the essential elements or characteristics of ideas of constant development, and scientific management. Despite their respective successes, Six Sigma and Lean both had drawbacks and limitations. In the 1980s, Motorola developed Six Sigma, and

in the early 2000s, Lean methods and Six Sigma were combined. (Snee, 2010; Linderman et al., 2003; Cherrafi et al., 2017). Many organisations were able to create high-quality brand identities early on in the Six Sigma method, but later on, some problems with expense and efficiency surfaced. (Besseris, 2014). Employee motivation rose as a result of the adoption of new quality procedures because they promote a positive work atmosphere. (Dahlgaard and Dahlgaard, 2003). For better and more effective outcomes, many businesses
have combined quality development techniques (Kumar and Antony, 2008; Kumar et al., 2016; Cournoyer et al., 2013), such as the use of LSS in manufacturing. (Franchetti and Yanik, 2011; Al-Aomar, 2012; Gibbons et al.,2012).

While Six Sigma focuses mainly on fixing quality-related problems by noting the number of process chances that could result in defects before they transformed into defects, Lean strategy is primarily focused on decreasing waste by encouraging value-added behaviour. (Antony et al., 2005; Ghane, 2014). Regarding the comparison of Six Sigma, lean, and shared tools between the two models, Antony, Escamilla, and Caine (2003), Pepper and Spedding (2010), Salah, Rahim, and Carretero (2010), and Pepper and Spedding (2010) found four comparable tools. (Figure-1). When combining the two approaches, it is crucial to decide whether to apply the value-adding step within the process itself or in between two stages.

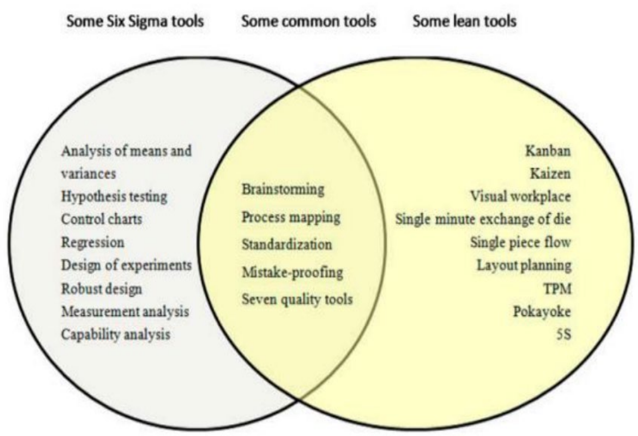

Figure 1 Six Sigma and lean common tool
Source: Antony, Escamilla, and Caine (2003), Pepper and Spedding (2010), Salah, Rahim, and Carretero (2010)

In a survey of 2215 businesses that used lean tools in conjunction with Six Sigma projects, Shah, Chandrasekaran, and Linderman (2008) discovered that some lean methods, depending on how they are applied, have a larger impact on Six Sigma projects than others. Lean and Six Sigma, they argue, should be viewed as complimentary approaches. (2006) Su, Chiang, and Chang conducted a case study on a company that offered IT help centre services. The major findings of the authors are that the company's service time was reduced by more than 52% when LSS was implemented, and the expense of operations was also decreased. Su, Chiang, and Chang (2006) listed some of the advantages of lean and Six Sigma in the same study as well as some of their differences, as shown in (Table-2).

Table 2 The benefits and challenges for Six Sigma and Lean.

Methodology	Six Sigma	Lean
Benefits	Uniform process output Defect reduction Cost reduction Productivity improvement Culture change Customer satisfaction Market share growth Product/service development	Cycle time reduction WIP reduction Cost reduction Productivity improvement Shorten delivery time Space saving Less equipment needed Less human effort
Challenges	System interaction is not considered because processes are improved independently Lack of specific speed tools Long project duration	Statistical or system analysis not valued Process incapability and instability People issues

Source: Adapted from Su, Chiang, and Chang (2006).

The many application areas have been well-illustrated by researchers with some fantastic instances. S. Singh gave an example of how supply chain and transportation can use both Lean and the standard six sigma method to raise the quality of service provided to customers. Numerous authors have shown the great benefits of using the Six Sigma method, but the real application in logistics is still well behind other industrial and service sectors; they discussed the difficulties encountered by Singaporean logistics applications. Researchers in Brazil found comparable issues with the six-sigma deployment logistics apps. The addition of this study demonstrates how the paradigm can be applied to the important problem of declining profit in the e-commerce sector.

3.0 Methodology

The information was gathered using primary sources. Sources were used to analyze the declining profits of the e-commerce sector. Case-based methodologies were used in both the poll instrument and the study. It is simple data that was collected throughout the course of the endeavor. Authors used information gathered from approximately 3000 points in the e-commerce industry that defined key processes to find a number of problems.

All previous defenses were reviewed, along with their level of success, and solutions were implemented as a result. The authors came to the conclusion that the only path to a more effective answer was to use the Six Sigma methodology, which included the DMAIC and DMADV problem-solving methods. These approaches vary in order to simultaneously but discretely target various business segments. The improvement of business processes is the only thing they have in common, and they support one another in the analytical processes.

The objectives and recommendations for both of these approaches are to use data collection and statistical tools to enhance company operations. For the given instance, the writers opt to employ the DMAIC paradigm. (Refer to table-3)

Table 3 Key Steps of Six Sigma using the DMAIC Process (McClusky, 2000)

Six Sigma steps	Key processes
Define	Define the requirement and expectations of the customer Define the project boundaries Define the process by mapping the business flow
Measure	Measure the process to satisfy customer's needs, develop a data collection plan Collect and compare data to determine issues and shortfalls
Analyze	Analyze the cause of defects and sources of variation, Determine the variations in the process Prioritize opportunities for future improvement
Improve	Analyze the cause of defects and sources of variation, Determine the variations in the process Prioritize opportunities for future improvement
Control	Design controls: make improvements, implement and monitor

We must be vigilant in our quest of excellence as we set out on this path of client involvement. From the first interaction with the customer to the time the purchase is made and finally received, it is our goal to watch and record every stage of the process. With this methodical strategy, we can collect important information and spot possible defect sources.
We will plan out the complete process so that we can focus specifically on the most important stages. As a result, we will have a thorough grasp of the client journey and be able to identify any areas that might need development.
We will gather information using a variety of methods to further improve our knowledge of flaws. Visual examination will be crucial in spotting any physical flaws, and client complains that have been documented will give us insightful feedback. Additionally, we will depend on the company's quality control records to make sure we have a full image of any potential problems.

4.0 Analysis

During the Define phase of the DMAIC journey, we embark on a crucial mission to not only expound upon and clarify the business quandary to all members of the organization, but also to meticulously delineate the metrics of the predicament and the undertaking at hand. This phase is paramount in laying the foundation for the remainder of the journey and requires a thorough and comprehensive approach to ensure its success. During this particular phase, a multitude of tools are implemented to serve the aforementioned objective. In this particular research we will be working with Pareto Chart and SIPOC Diagram.

A comprehensive and exhaustive analysis of data has been conducted to unravel the intricacies surrounding the predicament at hand. Initially, the business conundrum or, more aptly put, the issue plaguing the enterprise was pinpointed. In our scenario, we did the timeline trend study for the issue of timely deliveries (Figure-2) that has been afflicting the company. Upon the detection of the delivery issue as the primary business obstacle, we delved deeper into comprehending the ramifications of this issue. Through the utilization of a pareto chart, we were able to discern that timely delivery in Tier 1 and 2 cities (Figure-3) are being affected the most or we could say that these areas have the highest cases of delivery failure.

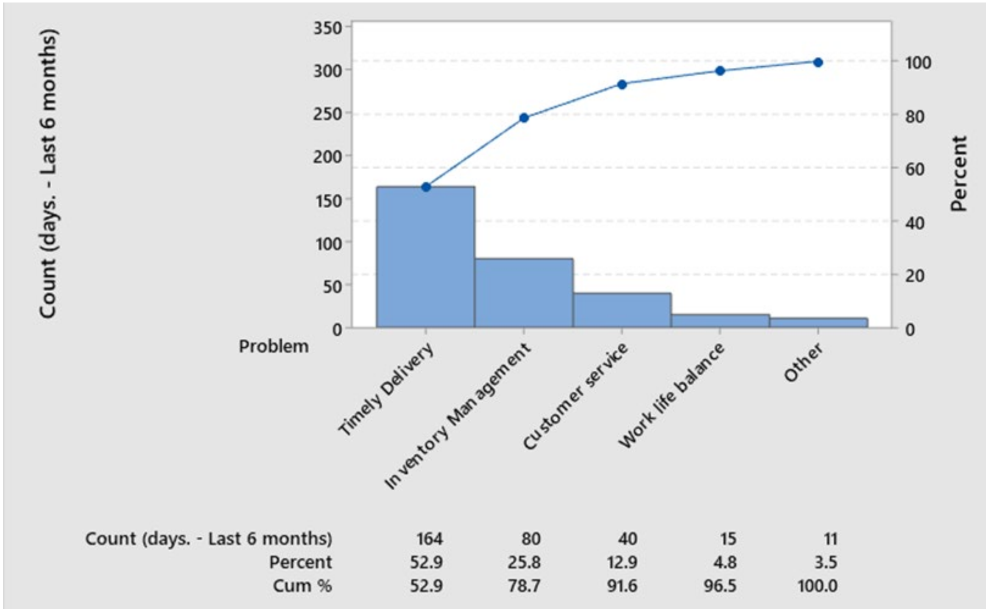

Figure 2 Pareto Chart showing prioritization of defects.

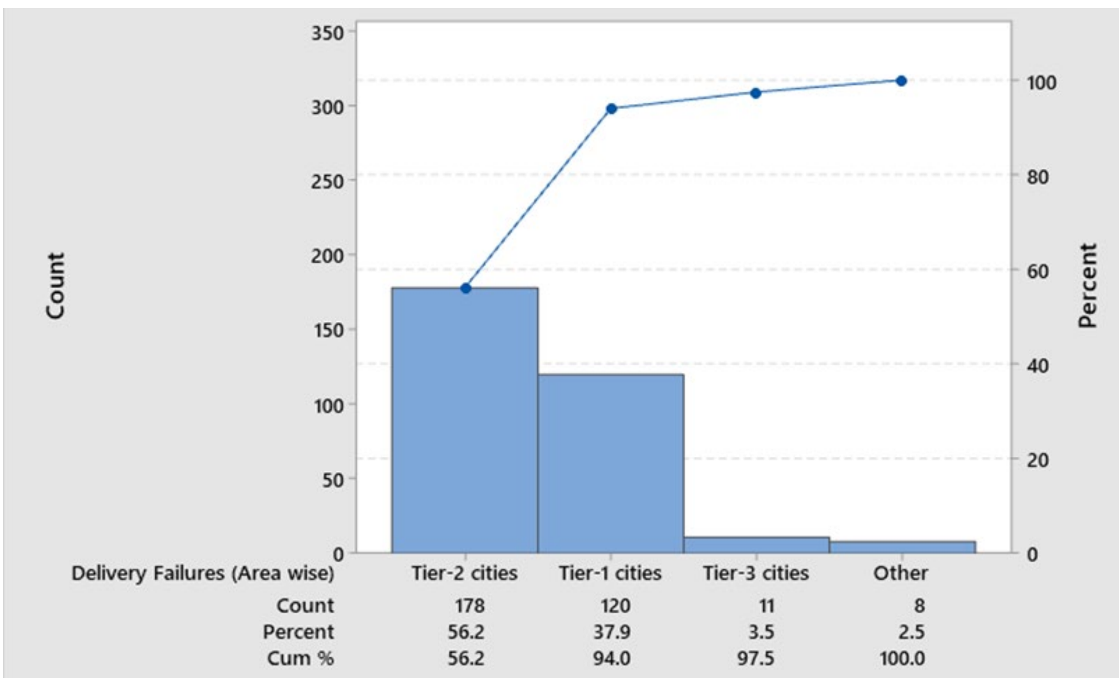

Figure 3 Pareto Chart showing delivery failures (Area wise).

The metamorphosis of inputs from suppliers to outputs for customers is a complex and intricate process that requires a deep level of comprehension. This process involves a series of interrelated sub-processes that must be carefully orchestrated to ensure optimal results. The correlation between these sub-processes is crucial, as any misalignment can result in a breakdown of the entire system. A high-level understanding of this process is necessary to appreciate the intricacies involved and to ensure that each step is executed with precision and accuracy. The figure below describes the SIPOC analysis of the e-commerce company.

SUPPLIERS Who supplies the process inputs?	INPUTS What inputs are required?	PROCESSES What are the major steps in the process?	OUTPUTS What are the process outputs?	CUSTOMERS Who receives the outputs?
Vendor-1	Product Information	Product listing and Management	Products Sold on the website	Individual consumer purchasing
Vendor-2	Technology Infrastructure	Order processing	Fast and Efficient Delivery	Prime members with other benefits
Vendor-3	Logistical Information	Payment Collection	Helpful customer support	Third-Party sellers
Third- Party Sellers	Customer Data	Logistics and Shipping Management	Cross-selling and Up-seliing	
Service Providers		Customer service and support	Financial data and report on sales and revenue	

Figure 4 SIPOC analysis.

Upon the successful conclusion of the Pareto and SIPOC diagram, the Define phase reaches its culmination through a comprehensive review and alignment towards the ultimate objective. This pivotal phase entails the formal training of all pertinent personnel and employees to illuminate them on the approach and scope of the project. Additionally, this training serves as a means to inculcate awareness throughout the organization, thereby bolstering the total employee involvement, which serves as a fundamental catalyst for the fruition of any given project (Montgomery, D.C. 2002).

During the measure phase, a comprehensive evaluation of the process is conducted to ascertain the underlying factors and root causes of any issues that may have arisen. This entails a thorough analysis of the process's overall state, with the aim of identifying any potential triggers or catalysts for the problem at hand. By carefully scrutinizing the process and its various components, we can gain a deeper understanding of the factors that may be contributing to the issue, allowing us to develop targeted solutions that address the root cause rather than merely treating the symptoms. In this pivotal stage, the paramount focus is placed upon the meticulous selection of product characteristics that are deemed appropriate. The next step entails the careful evaluation of the measurement system's accuracy, followed by the crucial task of making necessary measurements. The data gathered is then meticulously recorded, and a baseline of the process capability or sigma quality for the process is established. This stage is critical in ensuring that the product is of the highest quality, and that the process is optimized to deliver optimal results (Tarik and Ali, 2012). The tool which is used in this phase is Process mapping diagram.

Process mapping is a crucial tool utilized to ascertain the precise, stage-by-stage value enhancement of a product during the manufacturing process. This technique involves mapping the precise location of a given process, as well as the intricate flow and function performed on the product or process. By doing so, manufacturers can gain a comprehensive understanding of the intricate inner workings of their manufacturing process, allowing them to optimize their operations and enhance the overall value of their products.

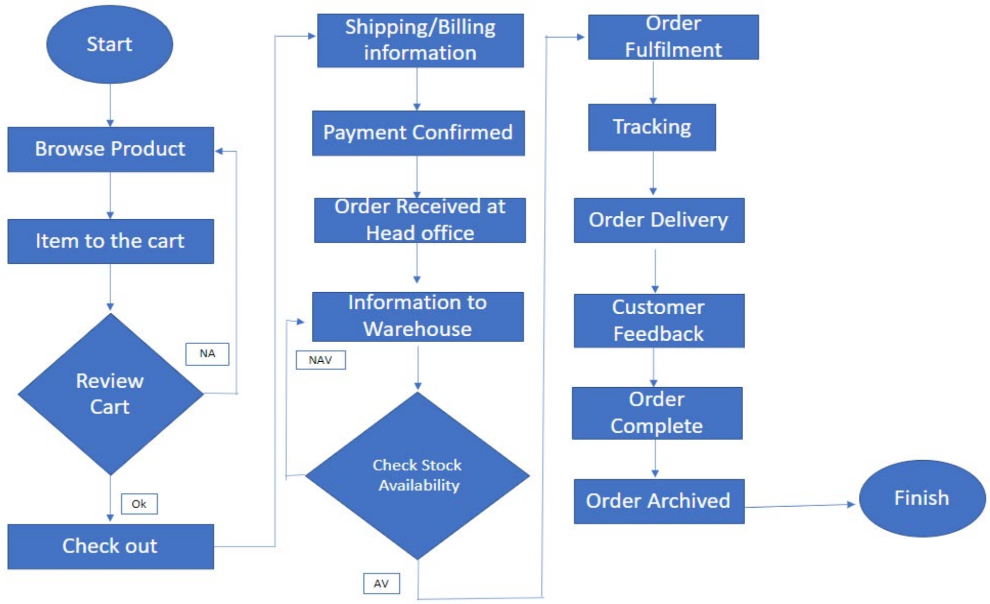

Figure 5 Process Mapping of an e-commerce company.

The cause-and-effect diagram, fondly referred to as the Ishikawa diagram or fishbone diagram, is a powerful tool utilized to unearth the fundamental cause(s) of a problem or issue. It is a visual representation that dissects potential causes of a problem into distinct categories, thereby simplifying the identification of underlying causes and devising solutions to tackle them. The diagram itself takes the form of a fishbone, with the "head" of the fish signifying the problem or issue being examined, and the "bones" of the fish symbolizing varied categories of potential causes (Kumar, M., Antony, J. and Cho, R. 2009). By breaking down the potential causes of the timely delivery issues into distinct categories, this cause-and-effect diagram can help identify the root causes of the problem and potential solutions to address them (Figure-6).

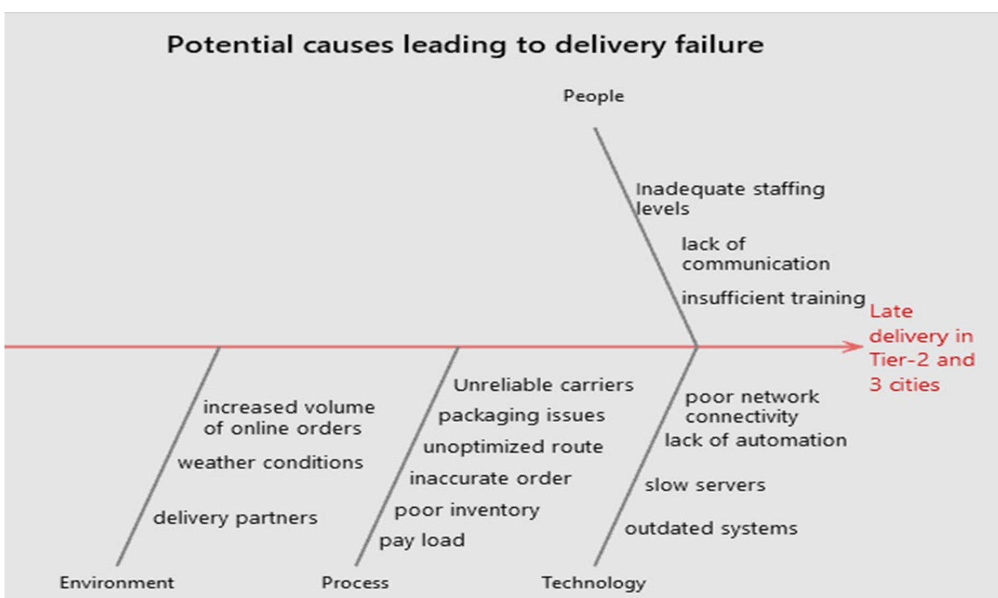

Figure 6 Cause and effect diagram.

The analyze phase is a crucial step in any problem-solving process. Its primary objective is to delve deep into the problem and identify its underlying causes. This phase also aims to generate ideas for improvement. To accomplish this, a variety of tools can be used, but one that is particularly effective in this scenario is the cause-and-effect analysis. This tool enables a comprehensive exploration of the problem, and the subsequent brainstorming session that was conducted in conjunction with it was instrumental in yielding valuable insights. By applying this approach, we were able to identify the root causes of the problem and generate innovative ideas for improvement (Desai & RL Shrivastava, 2008).

In this phase, we delve into the nitty-gritty of potential causes that have been identified through the use of a cause-and-effect diagram. It is crucial to determine the root causes of the problem at hand, and to do so, we must first validate the causes listed on the diagram. This validation process requires us to identify the type of data that could be collected on each cause. Only then can we truly understand the underlying factors contributing to the issue and develop effective solutions. After conducting a thorough validation of potential causes, we have identified a select few that warrant further analysis (Delivery Partner, Unreliable Carriers, Unoptimized Routes, Pay Loads). These 4 factors have been given priority and marked for immediate attention in our next course of action (Table-4). It is imperative that we delve deeper into these particular causes to gain a better understanding of their impact and potential solutions.

Potential Causes	Standard	Actual	Valid / Not Valid
Increased Volume of Online orders	Higher the better	Higher	Not Valid
Weather Conditions	Any weather (except rain)	As per standard	Not Valid
Delivery Partner	Amazon logistics licenced	Unlicenced	Valid
Unreliable Carriers (Vehicle Type)	Approved 4 Wheelers, 2 Wheelers	Unapproved vehicles	Valid
Packaging Causes	Standard packing material	As per standard	Not Valid
Unoptimized Route (Road Type)	Stated routes as per city	Different routes uses	Valid
Inaccurate Order	As per invoice	As per invoice	Not Valid
Poor Inventory	As per ERP	As per ERP	Not Valid
Pay Load	As per set parameter	As per carrier	Valid
Inadequate Staffing	As per requirement	As per requirement	Not Valid
Lack of communication	As per communication matrix	As per communication matr	Not Valid
Insufficient training	As per training plan	As per training plan	Not Valid
Poor Network Connectivity	As per channel matrix	As per channel matrix	Not Valid
Lack of Automation	As per requirement	As per requirement	Not Valid
Slow Servers	> 2MBPS server speed	> 5MBPS server speed	Not Valid
Outdated Systems	As per requirement	As per requirement	Not Valid

Table 4 Validation and identification of main causes.

DOE (Design of Experiments) - 2K factorial study is a statistical method used in experimental design to study the effect of two or more independent variables (factors) on a single dependent variable. The "2K" refers to the number of levels of each factor that are to be tested. Upon completion of the analysis phase, a comprehensive review of all factors contributing to the business problem is conducted. These factors are then meticulously examined and enhanced through the utilization of the powerful DOE tool (Design of Experiments).
We've identified some key causes that are integral to the delivery process, and unfortunately, we can't completely eliminate them. However, we can optimize them as much as possible through a

critical activity called Design of Experiments (DOE) during the improvement phase. This ensures that we're doing everything we can to make the process as efficient as possible.

Our team collaborated to generate various ideas, thoroughly analyzed and evaluated each one, and ultimately chose the most promising solutions. From there, we planned and implemented these chosen solutions to improve our process. It was no easy feat, but we worked together to achieve success (Antony, J. 2004; Antony, J. & Banuelas, R. 2001).

S	R-sq	R-sq(adj)	R-sq(pred)
79.8605	70.50%	59.77%	37.58%

Figure 7 Summary Model.

From the model summary we can clearly see that the R-sq is around 70% which means that all the inputs are contributing about 70% in the variance of the output (Figure-7).

Source	DF	Adj SS	Adj MS	F-Value	P-Value
Model	4	167631	41907.8	6.57	0.006
Linear	4	167631	41907.8	6.57	0.006
Vehicle type	1	689	689.1	0.11	0.749
Delivery Partner	1	52327	52326.6	8.20	0.015
Pay Load	1	65664	65664.1	10.30	0.008
Road type	1	48952	48951.6	7.68	0.018
Error	11	70155	6377.7		
Total	15	237786			

Figure 8 Analysis of Variance.

Through the analysis of Variance, we can see that the p-value for Vehicle type is more than 0.05 while the p- value for other factors like Delivery Partner, Pay Load and Road type are less than 0.05 which means that Vehicle type is not a major contributor to variance in output (Figure - 8).

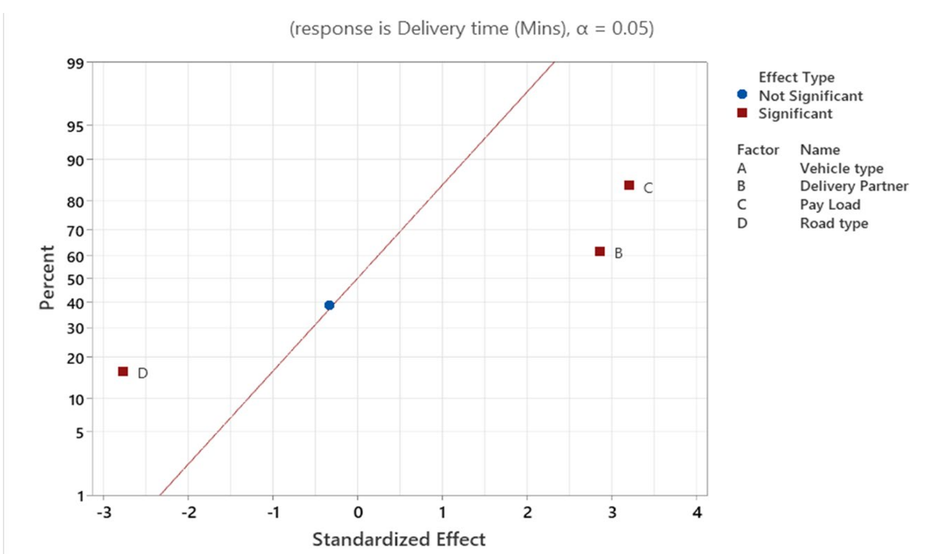

Figure 9 Normal Plot of the Standardized Effects.

Same could be illustrated by the normal plot of Standardized effects (Figure - 9) that factor A that is vehicle type is not significantly contributing in the variance or in the delivery time.

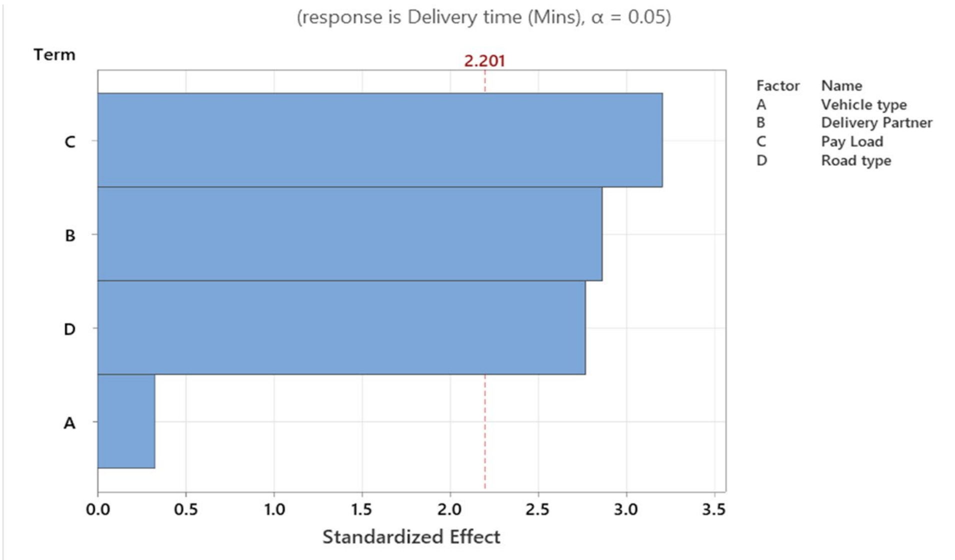

Figure 10 Pareto Chart of Standardized Effects.

The above Pareto chart represents the threshold for standardized effect i.e., 2.20 while Road type, Delivery partner, and payload have a standardized effect more than the threshold while Vehicle type has less standardized effect than the threshold signifies that vehicle type is not an important cause for the problem.

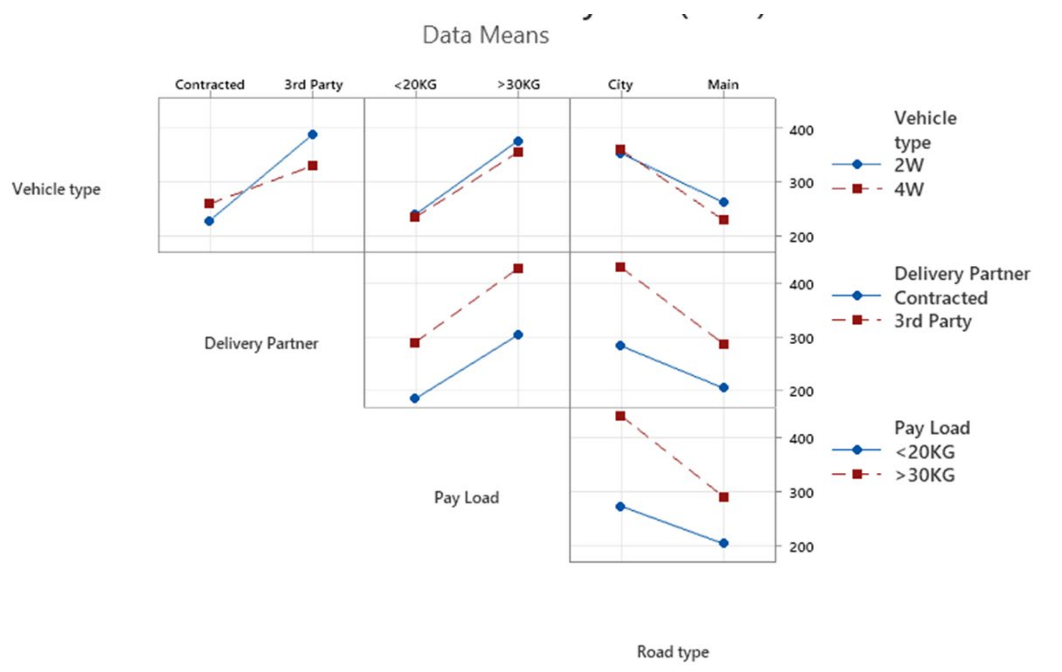

Figure 11 Interaction plot for delivery time (mins).

The graphic representation is undeniably illustrative of the interplay between the various factors, regardless of their degree of significance (Figure - 11). Through the interaction plot for delivery time, it is illustrated that the interaction between any two factors occurs only when vehicle type is taken into consideration but from the above analysis, we already concluded that vehicle type is not a significant factor, so we will be neglecting that. Also, the other three factors among each other show a parallel relationship which means these factors are contributing to the variance as a whole rather than in a pair.

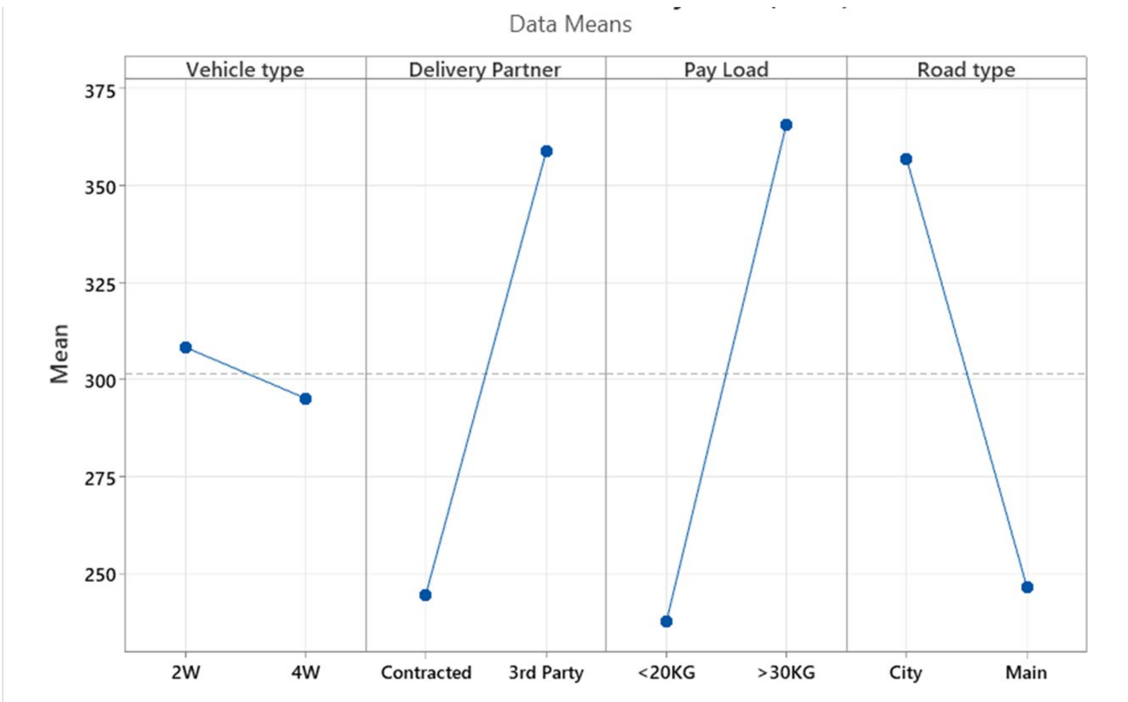

Figure 12 Main effect plot for delivery time (mins).

Upon conducting a thorough analysis, the process parameters underwent a rigorous optimization process utilizing a response optimizer. The resulting outcome yielded a solution that was remarkably close to being ideal for the process at hand (Figure - 12). There has been an exponential shift in the three factors (delivery partner, payload, road type) so controlling these factors will directly affect the delivery time.

In the control phase, the emphasis was to maintain the gains made by the project team. Taking all corrective actions during the phase of improvement, reviewing potential solutions on a regular basis, and adhering strictly to the process yield are all done. The cross-functional team took on the responsibility, examined the effects of each component, and put the answers they found into action. Also, efforts were made to keep up those principles on a practical basis (Gijo & Antony, 2012). All modifications have undergone standardization and have been recorded in the standard operating procedures. We have conducted hourly inspections and monitoring to ensure effective implementation of the following alterations.

For the Delivery partners, all the unlicensed parties should meet the company logistics licensing standards. All the vehicles should be approved either 4W or 2W by the company. The delivery partners should opt for the main road and stated routes as per the norms. Pay load should be as per set parameters.

5.0 Results

One of the most effective methods for enhancing the capability and quality of a process (whether it be manufacturing, service-related, or transactional) is Six Sigma. This method involves systematically lowering process variation, which raises the risk of unwanted defect rates and, ultimately, lowers customer satisfaction. As stated in the project charter, the purpose of this case study was to optimize delivery time. To address the problems with the unacceptable issues, a cross-functional team was established, and the team carefully adhered to the DMAIC process.

Figure 13 DOE Process optimization.

Following results were achieved through this project:

Process Optimization and parameter setting.
Vehicle type - 4W, Delivery partner - Contracted, Pay Load - <20kg, Road type - Main
Minimum delivery time of 118 minutes was achieved after optimizing the process.

Our team successfully minimized defects and achieved high levels of customer satisfaction.
As a result of their success in achieving the outcomes through a methodical approach, there was an increase in employee satisfaction and morale.

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