Effect of Lean Six Sigma on Order Fulfilment Process: Evidence from Manufacturing Companies in Gauteng, South Africa

by

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Thesis – 100% research project submitted in fulfilment of the requirements for the degree

M- Tech: Business Administration

in the Faculty of Business and Management Sciences

at the Cape Peninsula University of Technology

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District Six, campus
November 2023

DECLARATION

I, Vuyokazi Maku, declare that the contents of this thesis/dissertation represent my own unaided work, and that the thesis/dissertation has not previously been submitted for academic examination towards any qualification. Furthermore, it represents my own opinions and not necessarily those of the Cape Peninsula University of Technology.

Signed Date 7 Novemeber 2023

ABSTRACT

Lean six sigma (LSS) and order fulfilment are two of the most important aspects of any company, and they play a crucial role in facilitating global trade. A company with a sustainable and efficient lean process can easily meet client demands. It also ensures that consumer orders are processed quickly and easily, that products are readily available, and that goods are delivered faster and at a reasonable price to a global clientele. However, if it is not properly deployed and managed, it might prevent a company from competing effectively on a global scale.

To accomplish the goal, this study used a two-pronged approach. First, it critically examined several extant studies of the application of LSS to the order fulfilment processes in various manufacturing organisations. This assisted in detecting gaps in the available literature. Second, to overcome the highlighted problems, a quantitative methodology was adopted in this study with a survey questionnaire to operations managers, supply chain experts, procurement officials, consultants, and financial analysts from various manufacturing organisations. The data were collected using a case study with manufacturing firms in Gauteng Province, South Afrcia. The data from industry experts were analysed using deductive reasoning techniques. In this survey, random sampling was used because it provided each participant with an equal chance of being selected and it allowed for the selection of participants who matched those manufacturing professionals working in South Africa.

The findings of this study reveal that if lean six sigma is in place in most South African manufacturing firms, customers would not have any concerns about order quality and orders being delivered on time. This gives the company a competitive advantage in the worldwide market. The study confirms that implementing the lean six sigma performance indicator will result in a decrease in bottlenecks. However, communication is an important issue in applying LSS.

Keywords: Order fulfilment, Lean Six Sigma, Order process,Lean manufacturing, Six sigma.

ACKNOWLEDGEMENTS

I wish to thank:

- First and foremost, I want to convey my heartfelt thanks to my supervisor, Professor Bingwen Yan, for his unwavering support of my research and study, as well as his patience, vast knowledge, and inspiration. Throughout the research and writing of this dissertation, your guide has been quite helpful. For my master’s dissertation, I could not have asked for a better supervisor.

- To Dr Tshepo Phuti Mabotja, my co-Supervisor and the "brother" "I never had," words cannot convey my appreciation enough; your harsh and brotherly love, direction, encouragement, and research knowledge are valued beyond measure, Thank you Tata.

DEDICATION

First and foremost, I give thanks to the Lord, who is deserving of all glory and acclaim. It's impossible for me to list all of the things God has done for me.

To my late MOM, I devote my dissertation effort (Nontembiso Joyce Maku) to you. I wished you had lived a little longer to witness with your own eyes the work of your hands, May your unconditional loving soul rest in eternal peace ntomb’endala. Love you always Chayi!

Your words of encouragement and push for tenacity resonated in my ears, and I will always be grateful for everything you've done for me, my husband "Dr Lulamile Ntonzima."

My children, Asikelelwe Hlonela and Aphakama Thithiba, deserve special thanks for maintaining their composure throughout the travel while working late.

I owe a debt of gratitude to several people; I am confident that achieving this goal would have been far more difficult without them.

ACRONYMS

BOM	Bill of Material
BVA	Business Value Added
CVA	Customer Value Added
CTQ	Critical to Quality
DFSS	Design for Six Sigma method
DMAIC	Design Measure Analyse Improve Control
EDI	Electronic Data Interchange
ERP	Enterprise Resource Planning
GDP	Gross Domestic Product
HE	Higher Education
ILO	International Labour Organisation
IT	Information Technology
LMI	Lean Manufacturing Industry
LSS	Lean Six Sigma
LSSPI	Lean Six Sigma Performance Indicator
MRP	Material Requirement Planning
MRPII	Manufacturing Resources Planning
MSI	Medium Scale Integration
NVA	Non-Value Added
OEE	Overall Equipment Effectiveness or Efficiency
OFP	Order Fulfilment Process
OPP	Order Processing Process
QC	Quality Control
RoIC	Return on Investment Capital
SC	Supply Chain
SCM	Supply Chain Management
SAEIFSA	Steel and Engineering Industries Federation of South Africa
SPSS	Statistical Package for Social Sciences
SWOT	Strength Weakness Opportunities Threat
VOC	Volatile Organic Compound
VSM	Value Stream Mapping

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CHAPTER 1: INTRODUCTION

1.1 Introduction

This study examines how Lean Six Sigma (LSS) might improve order fulfilment in the South African manufacturing industry. Lean is a method to remove waste and Six Sigma is a scientific technique to reduce faults. Many firms wanting to maximise opportunities and reduce shrinkage have integrated the two approaches into LSS to exploit individual strengths and optimise workflow. LSS has improved operating procedures globally and Australia is a good example (Ahmed, Manaf & Islam, 2013).

Delayed orders affect customer service and lead to lost clients and income. According to Arndt *et al. (*2019), manufacturing has met major problems that demand fundamental adjustments. The authors claim that poor procedures duplicate services, increase wait times, and delay client orders. Rising costs and wastage cause higher expenses (Arndt *et al.,* 2019).

People find themselves in a market and business world where customer needs are most important; in terms of product quality, product pricing and delivery of product (Tampubolon & Purba, 2021). In order to effectively manage this requirement, the organisation should adopt a comprehensive concept and approach. In a systematic review, Tampubolon *et al. (*2021) show how LSS as a comprehensive concept and method can address these needs. The concept/method is implemented across various sectors or industries. LSS is used to help organisations enhance their competitiveness (Dragulanescu & Popescu, 2015; Rathilall & Singh, 2018), improve quality (Dragulanescu & Popescu, 2015), reduce costs, increase customer satisfaction, increase productivity, and increase employee morale (Tampubolon & Purba, 2021). The method must be revisited to ensure that the relevant concept and methods can contribute to business improvement and customer satisfaction.

Timans, Anthony, Ahaus, & van Solingen, (2012) indicated the problems that affect a company’s ability to achieve the above goals then these difficulties can hinder a manufacturing company's ability to provide exceptional customer service. LSS promotes waste reduction and service excellence. Many successful South African organisations have used LSS to synchronise their operations, but some disregard its significance and think it would be too expensive to implement.

This research study aimed to show how the LSS approach affects order fulfilment using data from South African manufacturers. The following sections introduce the justification for this study and the problem statement.

1.2 Background

To deliver outstanding product service, a company must give excellent customer service. Since "time is money," delivering things on schedule is one way to ensure client loyalty. If an organisation's structure preparation procedure yields little handling cycle time, products and services may be communicated easily (Sarkar, 2013). Several writers discuss order management. According to Shapiro *et al.* (2012), supply chain management (SCM) comprises order management, which involves eight main activities: order planning; order creation; cost estimating and pricing; order entry; selection; scheduling, and fulfilment. Incoming orders are handled by organisations via order management (Murphy, Otto, Yang, Jensen & Wood, 2014). This is the process that takes place between the time a company receives an order and the time the warehouse dispatches the necessary goods (Murphy *et al.,* 2014).

Order management is crucial to the supply chain's (SC) operational effectiveness and customer satisfaction (Khan, Jabber & Bonney, 2011). The stages involved in order processing are linked to the information flows of the system. To handle sales transactions, a sales order method generates internal documentation. Customers may have to complete a form to place a purchase; that is, in this process, they are sending orders and verifying them. The next step is checking the credit status and the availability of the item. Once packed and delivered with shipping documents, stock (or produced) products are later recovered. Customers must be kept informed of the status of the order. Historically, 70% of the order-cycle time was consumed by order processing (Kocaoglu & Acar, 2016).

The supply chain's time-based performance often decreases. Electronics and IT advancements in recent years have been beneficial. Merchants can rapidly identify products and adjust inventory levels using bar-code scanning. According to Ghiani *et al. (*2014), processing orders takes time (up to 70 per cent of the total order-cycle time). This has often hindered the time-based performance of SCs. Retailers can identify essential products and adjust inventory levels thanks to scannable bar codes. Salespeople may place orders and verify product availability in real-time using laptops and modems. Employing electronic data interchange (EDI), businesses may place orders for industrial goods without utilising paper (Ghiani, Manni, Musmanno, & Vigo, 2014).

LSS has become a crucial component of creating internationally competitive manufacturing firms because of globalisation, intense market competition, sustained industrial expansion, and rising customer expectations (Ismyrlis & Moschidis, 2015). This has made operational excellence possible. Organisations have a clear route to achieve their goals as quickly and effectively as possible thanks to time-tested methods (Psomas *et al.,* 2013). LSS is a combination of the two most significant continuous improvement methodologies, Lean and Six-Sigma. They are well-known and have shown how effectively a manufacturing organisation can manage processes and provide quality goods or services. Their operations appear to have provided a competitive advantage by raising the efficiency of the business' operational procedures (George, 2003).

Most manufacturing companies must use a range of techniques that have been successful in other contexts to recognise changes in their work environment, provide proactive feedback for continuous improvement, and boost performance (Fassoula, 2006). Many industrial companies in South Africa are implementing these methods, but it's not obvious whether the endorsement will improve company success (Emeka-Okolie *et al.,* 2008).

According to Guleria, *et al.* (2022), LSS is used by several African countries, including South Africa. Chow-Chua, Goh, and Wan (2003) stated that LSS is crucial for many types of businesses, including those in the manufacturing and mining industries, and that it enhances performance. The resources and capabilities of a company affect its performance and may give it a competitive edge (Martinez-Costa, Martínez-Lorente, & Choi, 2008). Performance techniques should be benchmarked (Raval, Kant, & Shankar, 2019), to provide businesses with a competitive advantage. These resources are unique, priceless, and irreplaceable to the organisation (Barney, 2007). Performance is based on assets and are often employed by rivals.

A manufacturing business must get sufficiently transportable resources that improve performance to keep its competitive advantage (Brown *et al.,* 2016). LSS is used to boost performance since the industrial sector has problems providing high-quality goods and services as rapidly and effectively as possible. Customers exert pressure on manufacturers to produce high-quality goods quickly, effectively, on schedule, and at prices that satisfy customers. According to Quazi *et al.* (2018), excellent performance may be attained when management methods prioritise quality. This includes the need for manufacturing companies to execute their tasks as efficiently and effectively as feasible to fulfil demand. Performance metrics that govern a company's management systems may be challenging to design, put into practice, and evaluate. How researchers view performance differs. Scholars and practitioners are interested in the recurrent theme of organisational performance in performance improvement (Venkatraman & Pinto, 2016).

The nature of the operations and products in the industrial sector hinders productivity. Industrial productivity is down, according to reports from the International Labour Organisation (ILO) (2015), Statistics South Africa (SSA) (2015), and Schwab (2019). According to Munyai *et al.* (2017), low productivity lowers South Africa's level of living. One of the main needs is for the manufacturing sectors to become more productive and participate in the international markets with efficiency in terms of delivery, pricing, and quality. However, several variables contribute to uncertainty and may affect output and market competitiveness. The manufacturing sector, which is more influenced by uncertainties and requires expert engineering management, is impacted by these issues. According to Teng (2014) productivity is the proportion of input to output. Productivity is the ratio of goods and services to labour and capital, with which inputs are turned into outputs in the manufacturing sector (Marsillac & Roh, 2014). This is evident from the standards established by the Association for Productivity South Africa (APPSA) and the Steel and Engineering Industries Federation of South Africa (SEIFSA) (Munyai *et al.,* 2017). SEIFSA estimates that the steel sector contributes seventeen per cent to South Africa's GDP (2015).

Company performance metrics include employee satisfaction, sigma manufacturing, corporate performance, productivity, and business outcomes (Madu *et al.,* 2011). The latter study's analysis of the firm's performance metrics demonstrates how LSS may boost performance by accelerating output. Productivity, efficiency, organisational performance, and employee satisfaction were described in that order in this study. What is process improvement? A process is a set of steps taken in the creation or delivery of something. Whether it's tying our shoes, making a cake, or treating a cancer patient, almost everything we do is a process. How can processes be improved? Employees must have a greater understanding of how a process may benefit customers if it is to be improved. Since every product or service is the result of a process, understanding how to reduce waste and enhance processes is essential for business development (Marka, 2015).

According to Madu *et al. (*2011) workers are given a strategy and toolbox by LSS to develop critical thinking. Lean and Six-Sigma both depend on the scientific method and foster a culture of critical thinking. "Discover a better method" should become a regular habit. Six-sigma and Lean both had their beginnings at Motorola in the 1980s. They were taught as distinct techniques for a while, but as the line between the two has become fuzzier, it is becoming more popular to combine them to achieve the best of both methods. Using toolboxes and being familiar with the two approaches is essential for issue resolution. Lean or Six Sigma tools are equally effective if they fulfil their intended tasks.

This is impacted by, among other, the development and retention of a skilled workforce, a lack of competitor knowledge, and operational inefficiencies caused by internal process issues such as the slow delivery of orders (Naude & Badenhorst-Weiss, 2011). Brand Pretorius, former president of the National Association of Automotive Component and Allied Manufacturers (NAACAM), hailed South Africa's automotive sector as a centre for excellence and strategic asset. According to Mackay, (2021) implored the industry to adopt a much more robust business model to withstand the changes in the environment.

Organisations from all industries need to adopt new, specific, strategic business practices or techniques to ensure that they can enhance operations and management philosophies (Ndaita, Gachie, & Kiveu, 2015). In turn, this ensures that they maintain a competitive advantage and market share; by ensuring that effective order processing becomes the norm. The Volatility, Uncertainty, Complexity and Ambiguity (VUCA) world and volatile markets require this approach.

1.3 Problem statement

Order fulfilment focuses on creating a competitive product. While efficient companies are known to produce superior products, the broader success of these products is also influenced by factors beyond their quality (Muganyi, Madanhire, & Mbohwa, 2018). Timely order fulfilment emerges as a critical driver of both client demand and satisfaction. However, a surge in orders leading to delays can result in the unfortunate consequence of lost consumers and financial setbacks.

The need for efficient order fulfilment practices is underscored by studies conducted in South Africa, as highlighted by Sreedharan *et al.* (2018). Their research indicates that the implementation of Lean Six Sigma (LSS) methodologies plays a pivotal role in preventing bottlenecks and disruptions in downstream operations. This, in turn, promises a significant enhancement in overall operational efficiency.

Further reinforcing the urgency of this problem, Mabotja, Mulongo, and

Kholopane (2018) demonstrate how late orders can result in divisions within the organisational structure, eroding consumer trust, and leading to financial losses. The adverse impact of delayed order processing is not confined to a single department; rather, it ripples through various aspects of the business such as engineering, materials management, and production (Cordero *et al.,* 2017).

In summary, the challenge at hand is to effectively address and rectify the inefficiencies and shortcomings within the order fulfilment process. The overarching goal is to implement strategies, potentially utilising LSS methodologies, to ensure timely and streamlined order processing. This, in turn, will mitigate divisional silos, bolster consumer trust, and ultimately lead to improved efficiency and financial performance across multiple operational domains.

1.4 The main aim of the study

This research aims to investigate the effect of Lean Six Sigma on the order fulfilment process in manufacturing companies.

1.5 Objectives of the study

The concise objectives of this study:

- Identify critical order fulfilment criteria in South African manufacturing enterprises.
- Examine Lean Six Sigma's manufacturing advantages.
- Determine Lean Six Sigma's problems in manufacturing.
- Make recommendations to enhance manufacturing businesses' order fulfilment.

1.6 Key research questions

The research has four broad questions pertaining to the study:

- What variables affect South African manufacturers' order fulfilment?
- What are Lean Six Sigma’s manufacturing benefits?

- What are Lean Six Sigma's problems in manufacturing?
- How may fulfilment defects be eliminated?

1.7 Research methodology

Secondary data sources were used and the reviewed literature formed the basis of the structure questionnaire design.

1.8 Research design and approach

The researcher used a descriptive survey approach in this quantitative research study since it accurately reflects a person's behaviour, attitudes, talents, beliefs, and knowledge. The study's objectives were to identify the advantages, difficulties, and solutions for lowering order processing mistakes as well as to investigate the applicability of LSS in South African manufacturing companies. To achieve the objectives of the study, a carefully constructed questionnaire was developed and administered to the research participants.

1.8.1 Quantitative research

Positivist researchers collect quantitative data and examine it scientifically. The use of quantitative research techniques is common since they deliver rapid findings, according to Liu & Van Ryzin (2008). This technique is also more efficient than testing hypotheses since it clarifies, counts, and builds statistical models to explain study findings.

1.8.2 Targeted respondents and area of research

The targeted respondents were manufacturing operations managers, production managers, supply chain specialists, consultants, financial analysts, and procurement authorities in South Africa.

1.8.3 Sampling

Random sampling was used in this study to give each respondent an equal chance of being nominated according to the same standards. A simple random sample is a portion of a statistical population with equally likely chances of selection. Simple random sampling accurately and impartially represents a group (Thompson, 2012).

1.9 Significance of the study

This study offers recommendations for enhancing order processing that might be used to shorten cycle times while keeping customer satisfaction levels high. Management will be able to use these results to apply Lean methods. The industrial sector will benefit from this study's advice on how to streamline order processes. The findings of this study may be used by future researchers to conduct new research on how LSS might improve business operations.

1.10 Limitations of the study

Study limitations include concerns with internal validity (Culler, 2009). The Gauteng manufacturing industry, South Africa, were the study focus. It was limited to manufacturing industry experts who agreed to participate. Survey time requirements and experts' reluctance to share knowledge that may have enhanced research results are limiting factors.

1.11 Structure of the study

The five chapters listed below comprise this study:

Chapter 1 explains the research topics, goals, as well as the importance of the manufacturing sector pertaining to the study. It contains the problem statement, justification for this research, concise objectives of the study and the research questions which conducts the study. The chapter also explains the significance and contribution of the study, limitations, delimitations and a brief introduction to the methodology of this research, the collection of data and its analysis.

Chapter 2 reviews the literature. This chapter builds on earlier research.

And provides the reader with context for the current study. The chapter concluded by identifying gaps in the extant literature that the research intended to address.

Chapter 3 describes the research methodology, the research approach, sampling, collection and analysis of data.

Chapter 4 focuses on findings following data results. It discusses the results and presents the researcher's interpretation of the research findings. The researcher appeals to the extant literature to support her claims and findings.

Chapter 5 presentsconclusion, recommendation and future research study.

1.12 Conclusion

The efficiency and competitiveness of the manufacturing process are increased through lean six sigma. To get supernormal results, a manufacturing company must improve the processes and efficiency of order processing. It is best to include this objective in its manufacturing strategy. According to research, businesses that do not implement LSS into their order or production processes start to fall behind their competitors. LSS methodologies are said to provide a competitive edge.

This chapter provided the background to LSS, the aim of the research , the problem statement, key questions of the research, objectives, the significance of the study and its limitations. The next chapter focuses on the review of the extant literature and provides further justification for the study.

CHAPTER 2: LITERATURE: AN OVERVIEW OF LEAN SIX SIGMA

2.1 Introduction

The analysis research on order processing in the manufacturing sector, notably, Lean Six Sigma operational performance. Order processing is one of the primary barriers to the successful completion of a manufacturing project. Operational performance in the manufacturing sector is one of the primary elements that contributes to delays, disruption of the production schedule, higher project costs, etc. Order processing and LSS are defined in this chapter. The reasons for processing delays, manufacturing order issues, as well as the advantages of implementing LSS in South African businesses are also discussed. The discussions in this chapter demonstrates difficulties of implementing six sigma in lean manufacturing and as well as in management techniques to avoid order fulfilment errors as gleaned from the extant literature.

In many countries, the Lean Manufacturing Industry (LMI) is essential for economic success. Manufacturers in developing countries need fundamental services like transportation (Buer, Strandhagen & Chan, 2018). The manufacturing industry may contribute to the socioeconomic growth of the country thanks to LMI principles. Manufacturing is important to the economy of any nation (Ghosh, Ma, Ofori-Opoku & Guyer, 2017). According to Gosh *et al. (*2017), LMI needs to oversee infrastructure planning and all phases of mechanical engineering tasks. Building trends are a major contributor to the economy of most countries since the industry employ both skilled and unskilled labour. The industrial sector is well-connected despite having a smaller GDP (Singh, Rathi & Garza-Reyes, 2021).

LSS are independent commerce change procedures and have distinctive execution measures. business improvement techniques and have different performance measures. The organisations provide with enhanced operational excellence for participation in the global economy. Continuous improvement is a shared feature. How the organisations achieve what distinguishes the two techniques. Each also has its inherent flaws. Despite the flaws, both systems are regarded as the forerunner systems for effectively improving business processes, including order processing (Rathilall & Singh, 2018).

Lean techniques ensure that wastes (e. g., over-production of work-in-process inventory, excess warehouse inventory) are eliminated throughout the business process so that orders are processed and delivered quickly (Liker, 2018). The underpinning theory for five guiding principles of methods of lean such as, a perspective of customer value definition, flow of stream identification of activities that add no value to the industry, ensuring that all processes run smooth, creating the systems that attracts and become effective (Andersson *et al.,* 2020). These, along with the requisite lean techniques and tools enhancing value-added constituents in any organisation. This is achieved by reducing human effort, space, and time as much as possible. The result is high-quality products are produced by paying attention to customer demands.

2.2 Understanding the Order Processing Process

The Order Processing Process (OPP) commences when client orders are received and ends when completed items are delivered. The period between receiving an order and shipping a product is known as the order fulfilment cycle time. The Order Fulfilment Process (OFP) is intricate and consists of several actions carried out by numerous functional entities. It is highly interconnected with the tasks, resources, and agents engaged in the process (Khan *et al.,* 2017). This process requires the coordination of several tasks, including those that generally take place across different business divisions, such as sales commitment, credit checks, production, logistics, accounts receivable, and partnerships with external suppliers for purchase or shipping (Leung, Cheng, Choy, Wong, Lam, Hui, Tsang, & Tang, 2017). The primary pursuits of the OFP may be summed up as follows:

- Order management, which commits order requests and takes client orders.
- Manufacturing, which includes shop floor control, material planning, capacity planning, and production scheduling.

- Distribution, which considers logistics including transportation and inventories.

Customers submit purchases via the sales department (Khan, Hasan, Ray, Saha & Abdul, 2013). Sales orders include order details, the item requested, the amount, the delivery date, and the prior balance order. All the details of a client order are documented in a sales order. The production department utilises the sales order to arrange its manufacturing line and timetable after passing it from the sales department. To ensure that there are adequate materials available to make the required products, the production department will also verify with the warehouse. The production department will propose that the buying department buy the missing materials if the raw material stock is not enough to manufacture the requested goods (Alfeno & Rifai, 2019). When the specified item is produced, a production report is generated and entered into the filing programme. When the purchasing department receives a material request from the production department, it issues a buy order to the supplier to deliver the necessary supplies. Additionally, the purchasing department will maintain track of the previous balance order, and suppliers will fulfil all requirements. Upon receiving the materials, the delivery order document will be stored in the file system (Laguna & Marklund, 2018).

2.3 What is Lean Six Sigma ?

Lean Six Sigma (LSS) is described as the hybrid methodology meant to solve global challenges and international constraints (Stern, 2016). Cost-effectiveness has made LSS popular. The Lean Manufacturing Industry (LMI) is large globally and contributes significantly to economic growth in many countries. By providing access to essential services and transportation infrastructure for emerging nations, the manufacturing sector contributes even more to their growth and the reduction of poverty (Odediran, Adeyinka, Opatunji & Morakinyo, 2012). Because of the products that come from the LMI's operations, this sector of the economy is significant. By supplying the resources needed for the manufacture of all items in the economy, the manufacturing industry aids in the socioeconomic growth of the country.

Manufacturing contributes significantly to the economy of all countries (Ofori & Hinson, 2007). According to Ofori (2000), Manufacturing includes the creation of materials, project documentation and processes, public and private sector agencies, and personnel, equipment, and contractors. The infrastructure's design is another responsibility of the manufacturing industry. Given that it includes all jobs related to mechanical engineering, it offers large job prospects for all skill levels, from entry-level to advanced. The developments in building have a significant impact on the economies of most nations. Consistent with Pandey *et al.* (2018) states that the manufacturing sector can be considered one of the most creative sectors in India and can play an important role in India's GDP development. In addition, Gaikwad and Sunnapwar (2020) state that in a globally competitive marketplace, operational and green performance has become a primary objective for organisations and this can be achieved through the adoption and integration of strategies such as Lean, Green Manufacturing and Six Sigma. Despite a lower GDP, the manufacturing sector remains robust due to its close ties to the rest of the economy (Ibrahim *et al.,* 2010).

Trewn *et al.* (2015) provide this additional definition of lean: "a never-ending, methodical strategy to discover and remove wastes and to improve process flow while engaging respondents." Although lean was created for the manufacturing sector, it can be used in any industry thanks to lean thinking. Since the consumer picks the value and price they are prepared to pay for the product or service, Lean is strongly focused on improving the quality of goods and services that are made available to customers (Liu *et al.,* 2020).

According to Sibalija and Vidosav (2012), the following are the lean methods:

a) Value stream: to identify the value-added as well as non-value-added operations in every manufactured goods for the process to flow smooth. The flow of value is structured in a manner where the delivery of goods or services, customer service must add value to what the consumer is expecting. The overall goal of any non-added-value operations for lean must be eliminated. In manufacturing an additional form of waste is regarded as a non-padded value. An operation below 1percent typically is a value added to the production whilst an ignorant of 99 percent chances of focusing on improving the resources by a percent.

(b) Value: the consumer's perspective about a specific product quality must be determined by value the manufacturer produces. When the customers last pull products in the production chain, every process is triggered concurrently.

(c) Flow: the value of flow is determined by consumer demand and developed with no disruptions. The evolving motion for goods and services that maintains the process flow of a single and work cell along a production line. When creating value steps, there must be a strict order to be followed in order the product runs smooth to get to the consumer.

(d) Perfection: the production to be pursued in steps in order to determine the value of activity stream is identified, waste of steps are excluded, and introduction of an effective flow and pull be in place, the conversion of a perfect value is determined by the improvement of waste reduction repeatedly.

The better performance of productivity is based on operation format of lean in manufacturing concept by reducing unwanted processes, therefore to maximise the customer value using limited resources is critical to lean manufacturing. Sabale and Thorat, (2019) indicated that waste is determined by the non-added-value activity in the customer perspective. Activities that do not add value from the customer's perspective are therefore futile (Sabale & Thorat, 2019). Six Sigma determines what customers expect from top quality products. LSS is the leading improvement methodology for every organisations. LSS' goal is to drive business improvement by integrating key capabilities of Lean (creating value and reducing waste) and Six Sigma (eliminating critical-to-quality (CTQ) problems) (Thomas et al. al., 2016).

The lean principles when performed correctly can have a significant effect on company effectiveness, cycle time, cost savings, and competitiveness (Udokporo, Anosike, Lim, Nadeem, Garza-Reyes & Ogbuka, 2020). Lean aims to eliminate waste (non-value-producing components in each process). Lean is not only meant for industrial production. Lean could indeed enhance how a group performs together by enhancing inventory management and even client interaction.

Hasan *et al.* (2013) state that the retailer will get the whole item from the manufacturer and stock every unit made. The store's records will be updated for each item that comes in and goes out. The business guarantees that all outbound products will be delivered timeously in the right amount and to the right client. The list record, according to Saha *et al.* *(*2013), is a record that details the things that logistics must choose to deliver all the final products to the consumer. Additionally, the client may place an order with sales. After the manufacturing department completes the order, the store issues a delivery order, which is sent along with the finished product. Consumers receive purchased goods for logistics (Kawa & Zdrenka, 2016).

Ten years from now, what is beneficial now might not be as relevant (Ellis *et al.,* 2016). All the steps taken to produce a product or service are included in a value stream. The effectiveness with which a product satisfies customer needs and its price determine its worth. After assessing its value, determine the value stream of the product or service. Six-sigma has a statistical antecedent and is dependent on mathematical process metrics. Sigma's normal distribution curve is formed like a six-bell. Number of standard deviations from the mean of the normal distribution curve with a bell-shaped form is six, according to Ptacek, Sperl and Trewn (2015). For more than 30 years, Six-Sigma has been used to enhance business operations and efficiency (Stern, 2016). Although increasing the sigma level provides many advantages, it also necessitates a lot of procedures and the efforts of many people.

2.4 Common factors affecting order processing

Murphy *et al.* (2014) defined Order management is the stage that deals with how a company processes orders. This is the sequence of events that occurs between the company receiving the order and the warehouse being instructed to ship the item as required (Laureani & Antony, 2019). Outbound logistics order managers need quick and reliable order information, according to Coyle *et al.* (2013). The efficiency of a Supply Chain's operations and customer satisfaction depend on proper order management (Khan, 2011). According to Shapiro *et al.* (2012), indicates that SCM in order management is the core processes, following which deals with six basic factors such as:

2.4.1 Planning tools

Tasks related to resource planning are included in planning tools for businesses and organisations. Material Requirements Planning (MRP), Manufacturing Resource Planning (MRP*II*), and Enterprise Resource Planning (ERP) are some of the most commonly used to plan technologies. MRP helps companies meet tight deadlines by planning production based on Bill of Materials (BOMs), levels of stock, and to excel in production schedules. Manufacturing capabilities and MRP's advantages are combined in MRPII. ERP combines all supply chain data processing activities. Customer service, order management, inventory delivery, production planning, and financial planning are often intertwined. It supports the logistical infrastructure of many businesses (Bowersox, Closs & Cooper, 2017).

2.4.2 Supply chain relationships

The importance of supply chain alliances in achieving company objectives cannot be overstated. Business success is aided by improved operational planning, vendor cooperation, and a greater comprehension of client wants. Relationship management and supply chain management involving suppliers and customers are linked (Fraza, 2020). Strategic supplier alliances and ties with customers allow knowledge sharing, one of the five pillars of a strong supply chain relationship (Lalonde, 2018).

2.4.3 Relationships with suppliers

Supplier relationships are common in businesses. Supplier collaborations must meet organisational needs. According to Hines (2014), the interaction between the buyer and seller of commodities is often adversarial and centred on price. Supply chain cost reductions are prevented by this supplier collaboration. Making connections and forming alliances with the provider to benefit both sides may be helpful. This could be focused on networking on a professional, personal, or symbolic level. This will lead to strategic partnerships that will facilitate information sharing, risk sharing, mutual benefit, and strategy coordination, all of which will enhance the supply chain (Hines, 2014).

2.4.4 Flexibility

Complex marketplaces, tough rivalry, and frequent demand adjustments require that organisations be flexible. Flexibility is the capacity to adjust and adapt swiftly to market changes by speeding up or slowing down production processes as required. Bowersox *et al. (*2017) assert that a company's logistical competence is measured by its capacity to adapt to unanticipated events.

2.4.5 Quality

Quality is expected, rather than demanded. Quality affects product acceptance. Bad quality affects pricing, efficiency, and market share (Dramm, 2000). Meeting or surpassing client expectations results in customer satisfaction (Bishop, 2020). Using quality metrics to improve the production process might help (Juran, 2018). Improved production, quality, productivity, and attaining the best product value at a reduced cost will boost a company's business performance.

2.5 Causes of delays in order processing

2.5.1 Poor scheduling and planning

Poor timing and planning are flagged by Shen *et al.,*(2017). The time management of a project or client order depends on the planning and scheduling of the activities (P&S). This usually is finished prior the beginning of construction that must involve procurement, as well as orders of pertinent goods. Otherwise, building delays are likely and that will cost money. It is crucial to make sure that supplies are always accessible on-site. Placing material orders up to six months in advance of the commencement of pertinent operations can achieve this. This was raised because of possible outcomes when the materials were about to be employed. Materials, for instance, might not be available or produced in domestic and foreign markets (e.g., because of a lack of supply orders from agents or users). Manufacturers might not be able to deliver (for example, due to over-ordering that exceeds production capacity), and alternative sources must be sought, and materials must be purchased at an expensive cost.

2.5.2 Unrealistic timeframes

Idris, Ugarte and Vansummeren (2017) claimed that unrealistic timeframes result in unreasonable timescales. The length of a project, which relates to the work schedule for the project plan is usually determined by the client or its representative. Contractors are required to meet the deadline to avoid fines for time overruns. Given the length of the project, the contractor must make sure that all the supplies are purchased in advance and are ready when required. However, some projects have unreasonably tight deadlines because of pressing events, like getting ready for an international conference or dealing with an emergency. Manufacturers must address these issues by locating sources for the quick supply of materials and guaranteeing that they are produced, although under exceptional circumstances and probably at a greater cost since such projects cannot be postponed (Patel, D'Alessandro, Ireland, Burel, Wencil & Rasmussen 2017). Significant delays stem from the failure to do so.

2.5.3 Order changes

Tafazzoli (2017) claimed that there are variations and alterations. In several nations. For example, in India, Iran, Kenya, and Malaysia, variations in orders and modifications to the scope of work specified in the tender are typical. They may occur in Brunei for example, for various reasons, including a lack of knowledge, changes in customer preferences, an inability to construct something exactly as planned, modifications to the design, unanticipated circumstances, or difficulties locating a necessary product. Changes impact materials for a variety of reasons. Either a new task that needs different materials or an addition to an existing piece of work that requires materials that have already been acquired or utilised might necessitate placing fresh orders (Sardroud, 2012). The materials must be imported from overseas if they are scarce or unavailable on the local market. Delays in the delivery of materials will follow and subsequently, result in delays in the completion of projects.

2.5.4 Logistics capacity

For logistics, there are cases where the number of requested products/materials is inadequate to fill a typical shipping container (Zhang, Mezzavilla, Zhu, Rangan & Panwar, 2017). These orders will be sent as a Loose Cargo Loads (LCL). This means that the volumes are palletised using heat treated wood in line with customs laws. These pallets are handled by regional vendors in Brunei. Pallets are sent to the forwarder when they make a material order, who subsequently transmits all orders to Brunei via Singapore (the source country). Therefore, assuming the manufacturer has stock, the shipping time from the source nation to Brunei doubles, in addition to the packing time. It would thus take around ten days altogether, provided there is stock with the manufacturer. It will take more time should the manfucturer does not have stock.

Habibi, Kermanshachi and Rouhanizadeh (2019) assert that there is a lack in raw resources. All materials received from foreign manufacturers are not entirely manufactured by its industry. There are occasions when certain raw materials—that is, substances or parts—are requested and brought in from other nations. For instance, Singapore is the source of imports for paint, while other nations are the source of imports for manufacturing. Although manufacturers normally have a specific quantity of raw materials on hand, a shortage might occur.

Son and Lee (2019) assert that decisions are taken gradually. The project is delayed while the contractor awaits authorisation to do certain tasks due to slow decision-making. Making decisions slowly was noted as asignifanct most causes of delays in research of a similar kind conducted in Kenya.
In Brunei, this is more typical when choosing designs and finishing materials such as tiles. The owner may easily make a decision to alter the project scope of work. An owner may easily decide to alter the project's scope of work, and they may also significantly affect project timetables by neglecting to reply to information requests for modification orders, or for choosing materials. Any last-minute choice, according to Abdellatif and Alshibani (2019), delay ordering supplies from abroad and thus delay delivery or delivery of material. While it takes longer, the prices are substantially cheaper than local markets. Certain local supplies are more costly, but can offset project delays to some extent. However, certain materials may not be locally provided or, if they are, their supply could not be adequate, in which case importing from outside is the only choice, causing a protracted delay.

2.6 The application and influence of LSS addressing defect in manufacturing industry

According to Daniyan et al. (2022) Lean Six Sigma is a powerful methodology that has gained significant traction in the manufacturing industry for addressing defects and improving overall operational efficiency. Combining the principles of Lean manufacturing and Six Sigma, this approach aims to identify and eliminate waste while reducing variation and defects in manufacturing processes. By adopting Lean Six Sigma, manufacturing companies can achieve higher levels of quality, productivity, and customer satisfaction, leading to a competitive edge in today's global market.

The application of Lean Six Sigma in the manufacturing industry starts with the identification of defects and their root causes. Through data-driven analysis, the methodology helps organisations pinpoint the key sources of defects, enabling them to implement targeted improvements and reduce waste. By streamlining processes and enhancing product quality, Lean Six Sigma enhances a company's reputation and customer loyalty, resulting in increased sales and market share. Lean Six Sigma also plays a crucial role in reducing production costs associated with defects. By identifying and eliminating non-value-added activities, companies can optimise their resources, reduce material waste, and minimise rework and scrap. This not only improves the bottom line but also strengthens the financial stability of the manufacturing organisation (Tampubolon, and Purba, 2021).

Yanamandra and Alzoubi (2022) states that one significant influence of Lean Six Sigma in the manufacturing industry is the cultural shift it brings about within organisations. The methodology encourages a data-driven and problem-solving mindset at all levels, fostering a culture of continuous improvement. Employees become more engaged and empowered to suggest and implement changes that lead to defect reduction and process optimisation. The emphasis on customer satisfaction is another essential aspect of Lean Six Sigma in the manufacturing industry. By reducing defects and enhancing product quality, companies can deliver products that meet or exceed customer expectations consistently. This not only enhances the company's reputation but also leads to increased customer loyalty and potential for repeat business.

The influence of Lean Six Sigma is not limited to the production floor; it extends to the product design phase as well. By employing Design for Six Sigma (DFSS) principles, manufacturers can proactively design products with fewer defects and easier manufacturability. This approach contributes to higher-quality products and a smoother production process. Manufacturing companies that adopt Lean Six Sigma also experience increased employee satisfaction and retention. The methodology encourages a supportive and collaborative work environment, where employees are actively involved in process improvement initiatives. This sense of ownership and pride in their work can lead to higher job satisfaction and reduced turnover rates (Titmarsh, Assad, and Harrison, 2020).

In conclusion, Lean Six Sigma has become an indispensable tool for the manufacturing industry, offering a structured and data-driven approach to tackle defects and optimise processes. Its application results in improved product quality, reduced costs, enhanced customer satisfaction, and a more efficient and agile manufacturing process. As companies continue to embrace Lean Six Sigma, they position themselves for sustainable growth and success in an increasingly competitive market.

2.6.1 Lean Six Sigma in Addressing Defect Identification in Manufacturing Industry

The roots of Lean Six Sigma trace back to Toyota's production system (TPS) and Motorola's Six Sigma philosophy. By combining these two methodologies, Lean Six Sigma was born, aiming to create a harmonious, defect-free manufacturing process. The adoption of Lean principles streamlined operations by eliminating non-value-added activities, while Six Sigma provided statistical tools to measure and reduce process variations leading to defects. One of the primary influences of Lean Six Sigma in the manufacturing industry is its emphasis on defect identification and root cause analysis. By using various tools like Fishbone diagrams, 5 Whys, and statistical analysis, Lean Six Sigma practitioners can trace the root causes of defects, enabling organisations to implement targeted and effective solutions(Singh *et al.,* 2020).

Lean Six Sigma targets waste in all forms, including overproduction, waiting times, and defects, to optimise production processes. By addressing defects and preventing errors at the source, companies can avoid costly rework and reduce overall waste, leading to improved efficiency and cost-effectiveness. Lean Six Sigma fosters a culture of continuous improvement within manufacturing organisations. Employees are encouraged to identify defects and suggest improvements, creating a collaborative environment that empowers workers to contribute to the company's success actively (Li *et al.,* 2019).

Implementing Lean Six Sigma methodologies in manufacturing processes leads to significant improvements in product quality. As defects are systematically addressed, the number of defective products reaching customers decreases, resulting in enhanced customer satisfaction and increased brand loyalty. Lean Six Sigma emphasizes standardizing processes to reduce variation and ensure consistency. This standardization enables organisations to control their manufacturing processes more effectively, reducing the likelihood of defects and ensuring high-quality output (Nandakumar *et al.,* 2020).

Lean Six Sigma relies on data-driven decision-making rather than intuition or assumptions. By collecting and analyzing data, organisations can make informed choices to improve their manufacturing processes systematically, leading to reduced defects and increased efficiency. The influence of Lean Six Sigma in addressing defects has substantial financial implications for manufacturing companies. Through the reduction of defects, organisations save on rework costs, lower the number of warranty claims, and minimize customer complaints, resulting in increased profitability and competitive advantage. Lean Six Sigma's defect reduction efforts indirectly contribute to sustainability and a reduced environmental footprint. By producing fewer defective products, companies decrease the amount of waste generated and resource consumption, aligning with environmentally friendly practices (Alzoubi et al*.,*2022).

In conclusion, Lean Six Sigma has a profound influence on addressing defects in the manufacturing industry. Its focus on continuous improvement, waste reduction, and data-driven decision-making enables organisations to identify root causes, optimise processes, and enhance product quality. By fostering a culture of quality and efficiency, Lean Six Sigma ensures customer satisfaction, financial benefits, and a positive impact on the environment. Manufacturing companies that embrace Lean Six Sigma methodologies are better equipped to remain competitive, deliver superior products, and thrive in a rapidly changing global market.

2.6.2 Lean six sigma development in reducing waste and defects

The concept of lean manufacturing revolves around the idea of streamlining processes by eliminating any non-value-adding activities, often referred to as waste. These wastes can manifest in various forms such as excessive inventory, overproduction, waiting times, unnecessary transportation, and more. By meticulously scrutinising each step in a process, Lean Six Sigma practitioners aim to create a smoother, more efficient workflow that conserves resources and time. The reduction of waste not only optimises resource allocation but also enhances the overall agility of an organisation, allowing it to respond more effectively to market demands and changes (Yeh et al.,, 2021).

On the other hand, Six Sigma focuses on the reduction of defects and variations within processes. It employs statistical methods to identify areas of potential improvement, aiming to bring processes to a state of near-perfection where the occurrence of defects is minimised (Evans and Lindsay, 2014). By analysing data and pinpointing the root causes of deviations, organisations can implement targeted solutions that eliminate errors at their source. The synergy of Six Sigma with lean principles creates a comprehensive framework that addresses both inefficiencies and quality issues in tandem, resulting in a more holistic approach to process enhancement.

Rathilall and Singh (2018) says that the integration of lean and Six Sigma into a single methodology capitalises on their respective strengths, resulting in a more robust approach to process improvement. Lean emphasises the efficient utilization of resources and the removal of non-essential activities, while Six Sigma ensures that the remaining processes are finely tuned to reduce defects and variations. This integration enhances the overall competitiveness of organisations by not only making them more agile and responsive but also by boosting customer satisfaction through the delivery of high-quality products and services. In practice, organisations adopting Lean Six Sigma embark on a structured journey known as the DMAIC (Define, Measure, Analyse, Improve, Control) process. This structured approach guides teams through problem identification, data collection, root cause analysis, solution implementation, and ongoing monitoring. By following these steps, organisations can systematically identify areas of waste and defects, leading to sustainable improvements that have a lasting impact on both operational efficiency and product/service quality.

In conclusion, the concept of Lean Six Sigma is a formidable force in modern process improvement strategies. By synergising the lean principles of waste reduction with Six Sigma's focus on defect minimization, this methodology provides organisations with a comprehensive toolkit for enhancing efficiency, quality, and customer satisfaction. As industries continue to evolve and competition intensifies, Lean Six Sigma remains a critical methodology for organisations striving to achieve operational excellence and maintain a competitive edge in the marketplace.

2.6.3 Process application of lean six sigma in manufacturing industry

According to Sreedharan and Sunder (2018), the process begins with defining the project's scope and goals. Manufacturers identify specific problem areas or processes that require improvement. This could include reducing defects, improving cycle times, enhancing product quality, or streamlining production flow. Clear and measurable objectives are set to ensure the success of the initiative. Once the scope is defined, the team collects data on the existing process. This involves mapping out the current process flow, identifying bottlenecks, and gathering data on process performance. The data is analysed using various Lean Six Sigma tools such as value stream mapping, process capability analysis, and root cause analysis. This analysis provides insights into the areas that require improvement and helps prioritise improvement efforts (Sreedharan and Sunder, 2018).

Next, the team applies Lean principles to eliminate waste and non-value-added activities. This involves streamlining the production process, reducing inventory levels, and improving material handling. By eliminating waste, manufacturers can optimise resource utilisation and reduce production costs. Simultaneously, the Six Sigma methodology is applied to reduce process variation and defects. This involves statistical analysis of process data to identify the root causes of defects and variation (Antony,2011). The team uses tools like statistical process control (SPC), design of experiments (DOE), and hypothesis testing to make data-driven decisions and implement process improvements.

During the implementation phase, the team may pilot test proposed changes on a smaller scale before rolling them out across the entire manufacturing process. This allows for fine-tuning and validation of the improvements before full-scale implementation. Regular monitoring and control are critical to sustaining process improvements. Key performance indicators (KPIs) are established to measure the effectiveness of the changes. Continuous data collection and analysis help ensure that the process remains on track and deviations are promptly addressed(Antony,2011).

Laureani and Antony (2017) sates that Lean Six Sigma approach also emphasizes employee involvement and engagement. Manufacturers actively involve their workforce in the improvement efforts, encouraging suggestions for process enhancements and providing training on Lean Six Sigma principles. This fosters a culture of continuous improvement and empowers employees to take ownership of their work processes. Incorporating Lean Six Sigma in the manufacturing industry also extends beyond the production floor. The principles can be applied to the supply chain and logistics to optimise material flow and reduce lead times. By collaborating with suppliers and customers, manufacturers can further enhance efficiency and meet customer demands more effectively.

In conclusion, the application of Lean Six Sigma in the manufacturing industry offers significant benefits, including increased productivity, improved product quality, reduced lead times, and lower production costs. By systematically identifying and eliminating waste and process variation, manufacturers can enhance their competitive advantage and deliver higher value to customers. Continuous improvement through Lean Six Sigma becomes a core part of the organisational culture, ensuring sustained success and adaptability in a dynamic manufacturing landscape.

2.6.4 The adopting of lean six sigma in minimizing manufacturing defects

The adoption of Lean Six Sigma methodologies has emerged as a transformative strategy in the realm of manufacturing, aimed at minimising defects and enhancing overall process efficiency. This amalgamation of Lean principles, which focus on waste reduction and streamlined processes, with Six Sigma's data-driven analytical approach creates a powerful framework for identifying and rectifying the root causes of manufacturing defects. By applying Lean Six Sigma principles, organisations can significantly improve their production processes, leading to higher quality products, reduced waste, and increased customer satisfaction (Sunder et al.,2020).

Stamatis (2019) opines that at the heart of Lean Six Sigma lies a commitment to identifying and eliminating sources of waste and variation within manufacturing processes. This entails a thorough analysis of every step of the production journey to identify potential bottlenecks, inefficiencies, and defects. By meticulously examining these aspects, manufacturers can target specific areas for improvement, deploying techniques such as process mapping, value stream analysis, and DMAIC (Define, Measure, Analyse, Improve, Control) cycles. This systematic approach not only helps in pinpointing the causes of defects but also in devising effective strategies to mitigate them.

One of the key strengths of Lean Six Sigma is its data-driven nature. Utilising statistical tools and techniques, organisations can gather, analyse, and interpret data related to defects and process performance (Clancy *et al.,* 2022). According to Huang *et al*. (2023), this empirical approach enables manufacturers to make informed decisions, prioritize improvements based on their impact, and monitor the progress of defect reduction efforts over time. By employing statistical process control, root cause analysis, and regression analysis, among other tools, manufacturers can gain valuable insights into the factors contributing to defects and take corrective actions accordingly.

Yadav et al. (2021) says that, the adoption of Lean Six Sigma fosters a culture of continuous improvement within manufacturing organisations. It encourages cross-functional collaboration, where teams work collectively to identify and address defects rather than placing blame on individuals. This collaborative environment promotes knowledge sharing and skills development, ultimately leading to a workforce that is empowered to proactively contribute to defect reduction initiatives. As a result, defects are not viewed as isolated incidents but as opportunities to enhance processes, thereby fostering a culture of learning and growth.

In summary, the adoption of Lean Six Sigma has emerged as a potent strategy for minimising manufacturing defects. By leveraging the principles of waste reduction, data-driven analysis, and a commitment to continuous improvement, organisations can systematically identify the root causes of defects and implement targeted solutions. This approach not only enhances product quality but also improves overall process efficiency, reduces waste, and elevates customer satisfaction. As the manufacturing landscape continues to evolve, Lean Six Sigma provides a reliable framework for organisations to remain competitive by delivering defect-free products that meet and exceed customer expectations.

2.7 The main benefits of implementing Lean Six Sigma

2.7.1 Reducing project lifecycle time

A company's project timeline regularly changes because of a change in the project scope or management philosophy, claims Mahomed and Peters

(2016). One may put together a group of seasoned experts from various departments and roles using the six sigma methodology. This team would pinpoint significant project-delaying problems. The project manager will assign the timelines to find solutions after identifying the root cause.

2.7.2 Customer satisfaction

According to Marajh *et al.,(*2017), LSS enhances business operations and quality control. Low failure rates, low prices, and high quality are characteristics of better-finished goods. Customers like purchasing high-quality goods. Customer loyalty, often known as customer satisfaction, is a vital performance measure. Only happy customers will stay loyal. Recent estimations indicate that six-sigma-using companies get a 40% greater Return on Investment (ROI) than their non-using counterparts. According to Heuhn-Brown and Murray (2010), many customers refrain from doing business again because they were dissatisfied with their interaction or because of the demeanour of the staff. The issue is that companies are oblivious to consumer dissatisfaction, which lowers levels of customer loyalty. By identifying the main causes that addressing key elements of customer satisfaction with service or product, six sigma reduces the likelihood of dissatisfied consumers. Key workers' six sigma training can help firm process wrinkles and rebuild customer confidence via better quality and service.

Globalisation has made customer satisfaction even more important for manufacturing companies. Especially when it comes to lead times, which determine the time from a customer's order to delivery. Therefore, the success and sustainability of a company in the global market requires short delivery times, fast order processing, and customer satisfaction in terms of meeting product quality requirements (Moser, Isaksson and Seifert, 2017). How to first use Six Sigma to improve process efficiency and then Lean to improve system efficiency.It is recommended to use both at the same time to realise the concept of integration.

To successfully integrate lean and six sigma, Organisations must implement a comprehensive improvement strategy in which are mutually reinforcing. Integrated approaches include using the current VSM as a platform to implement six sigma and lean tools, using six sigma to tune parameter processes, integrating lean technologies into DMAIC, It is expected to involve changing the process structure using a future state of VSM that is. The combination of lean and six sigma solves all shortcomings for both because they complement one another. Organisations can increase their potential improvements by combining the two (Bhuiyan and Baghel, 2005). Six sigma and lean integration assist businesses in achieving no defects, quick delivery, cost effective.

A detailed description of any integration is necessary for the company to successfully exceed upcoming customer requirements. Several studies on the use of LSS have been published by various authors, not confined to the manufacturing sector.

According to Madsen, Risvik, and Stenheim (2017), the Norwegian municipality public sector has implemented Lean as a tool used to manage to improve productivity and order fulfillment efficiency. Chiarini (2012) describes the use of lean six sigma as a management risk and cost effectivitiy tool for oncology drugss in healthcare. Furterer and Elshennawy (2005) used lean six sigma to reduce linen loss in acute care. According to Madsen, Risvik and Stenheim (2017), the Norwegian municipal public sector has implemented Lean as a management tool to improve productivity and order fulfilment performance. Chiarini (2012) describes the use of Lean Six Sigma as a risk management and cost reduction tool for oncology drugs in healthcare. Elshennawy *et al.* (2012) used Lean Six Sigma to reduce linen loss in acute care hospitals. Bazrkar, Iranzadeh, and Farahmand (2017) reported applying Lean Six Sigma to the in-service industry to improve efficiency and performance.

The LSS, DMAIC method is used in order to solve the problem of non-compliance with the quality of customer specifications in computer design service systems. As a result, they found the root cause of the issues and addressed these to improve the situation in a sustainable way (Bazrkar *et al.,* 2017; Rameni & Banuelos, 2018). Understanding barriers and motivations is essential for successful six sigma implementation. Six-sigma aims to perfect each production process (Narula & Grover, 2015). The target is a success rate of 99%. Therefore, LSS allows organisations to conduct a status and order processing analysis to implement improvement decisions (Erbiyik & Saru, 2015).

2.7.3 Reduce operating costs

Defective systems cost every organisation money, according to Munyai *et al.* (2017). Improving an organisation's activities is one of the best methods to save expenses. Six-sigma DMAIC aims to improve processes (Define, Measure, Analyse, Implement and Control). The six-sigma technique reduces problems to 3.4 defects per million opportunities, according to statistics. By reducing the amount of time your company spends repairing defective products, you can lower your cost of achieving quality by tenty percent and increase your operating profit by ffty percent (Nambiar *et al.,* 2015). The same can be done in many places, ensuring that your activities achieve new levels of cost-effectiveness.

Lean production is a set of values adopted by manufacturing companies to enhance production performance and satisfaction with customers while lessening waste and enhancing internal processes such as customer orders and planning (Ahmed *et al.,* 2018). It is commonly used in manufacturing and supply chain management, but has recently attracted attention from other discrete industrial companies (Mwacharo, 2013). Quality assurance as well as dependable performance have become primary considerations for manufacturing industries to achieve customer satisfaction as such the product demand grows (Adeodu, Kanakana & Rendani, 2021). For continuous productivity and quality improvements, various methods, approaches, and tools are used (Gupta *et al.,* 2020). Apart from these, every corporation or manufacturing industry appropriately select or combine different approaches or tools in the implementation process (Sokovic, Pavletic & Pipan, 2010).

Downtime and variability are inevitable during product manufacturing, but a major goal of process control or process capability analysis in an organisation is to investigate the causes of downtime during the product manufacturing process (Chen *et al*. 2017). This allows manufacturers to monitor and measure the potential of their processes (Wu *et al.,* 2013).

2.7.4 Improved employee performance

According to Munir *et al.* (2018), LSS is not only about firm management; it is about the team's daily work. Employees would do a great job and achieve the desired results. Dauada *et al.* (2011) further opines that not only are customers happy with six sigma; staff are happy too. A business's success depends on its employees' ability to act and react appropriately – nonetheless the only requirement I ensure that employees are sufficiently motivated. The businesses that can adequately involve their workers have consistently reported a 25–50 % increase in productivity. Providing the workers with six sigma training will enable them to learn new tools and strategies, allowing them to advance their careers and create a positive work atmosphere that results in highly satisfied employees with increased motivation.

2.7.5 Helpful in enterprise strategic planning

According to Anthony (2012), six-sigma is essential to the development of corporate strategy. Once the company has a goal statement and SWOT analysis, six sigma may assist to focus on areas that need to improve. By lowering product flaws and ensuring product functionality and service quality, six sigma may be utilised to enhance both internal and external operations. The organisation will succeed with the help to six sigma. According to Habidin (2013), businesses in today's service-based society must adapt to changing customer expectations. Six sigma may be a useful and strategic process improvement tool in this respect to maintain consistency in its output. LSS adoption resulted in a cultural shift that may be viewed as a framework for increased operational excellence and increased productivity.

Continuous process improvement is a central aspect of total quality management (Chen et *al.,* 2021). This can also be achieved via reengineering or computerised, and lean in manufacturing (Gupta *et al.,* 2020). The multidimensional production optimisation in Lean manufacturing approach incorporates several management practices intending to reduce unwanted product and increase operational effectiveness (Roriz, 2017). Implementation in the manufacturing sector includes non-tangible change factors; a learning environment support and the development of leadership (Gupta *et al.,* 2020).

The end of businesses are now adopting a strategy of continuous enhancement in the quality of the order processes to retain the customer and capture more market share (Chen *et al.,* 2020). In 2008, a crisis of economical international market was severely destabilised as consumer demand and industrial production dropped (Saidul Huq *et al.,* 2018). Firms, especially those in the process industry, had large amounts of inventory that could not be cleared due to declining sales (Atieh *et al.,* 2016). Resulting in a significant reduction in manufacturing industry, particularly in the European Union and the United States (Adeodu, Kanakana-Katumba & Rendani*,* 2021).

2.8 The challenges of implementing Lean Six Sigma

Marodin and Saurin (2015) assert that a continuous improvement program's failure might be attributed to a lack of desire or insufficient implementation motivation, as well as an incorrect understanding of the expectations. Before implementation gets underway, it is important to establish early in the process that the organisation can initiate change, cope with it when it occurs, and reform itself. Areas of risk associated with implementing Lean have been identified and grouped into three categories, including process management, upper and middle management support, and shop floor involvement. Process management has been shown to present most of the risks for these three factors, including lack of interest, knowledge, communication, and difficulty in visualising perceived benefits (Mclean & Anthony (2014).

2.8.1 Lack of engagement from employees

Employees are the foundation of every business, according to Yadav, Jain, Mittal, Panwar and Sharma (2019), and are thus essential to the implementation of lean. To successfully apply lean, workers must be involved in the process and be the driving force behind Continuous Improvement, which is a core feature of lean. The organisation will have a strong lean culture if it supports a lean programme and encourages employees and management to embrace change and shift their attitudes toward Continuous Improvement. Lean adoption would be viewed as a failure if it did not have the support of the organisation's employees. Additionally, the success of the lean adaption is negatively impacted by employee hostility, which results from a lack of comprehension of the need for change and opposition to the lean implementation process.

Dahl (2019), argues that the success of a lean company is dependent on the motivation and understanding of goals and objectives of the organisation's employees. Also, the company must have confidence in and support for the lean transformation to succeed. Workers need to understand the aim of lean improvements and have access to all the necessary resources to keep the system stable. An organisation with strong levels of employee loyalty and engagement will have lower employee turnover, more improvement initiatives completed, and a greater possibility of success in maintaining these changes (Ahmad, 2013). It is becoming increasingly important to allow employees to participate in decision-making and to contribute to the long-term vision of the organisation. The elimination of non-value-adding tasks and the minimisation of waste are essential tenets of the lean organisational culture. It also emphasises the significance of the company's workers in achieving success. It is impossible to build a successful lean system if respondents are not involved in the process (Al-Najem, 2014).

Both senior management and staff at the questioned firms are being discussed. The lean idea and culture are inextricably linked to respondents (Manni *et al.,* 2010). Several well-known lean thinkers have emphasised the significance of respondents in lean. Turesky *et al.* (2010), talks about the lean notion of "respect for respondents." Womack *et al.* (2021), discusses collaboration, communication, and continuous development. Human resource management is essential in lean methodologies, say Shah *et al.* (2007). In his discussion on culture, leadership, communication, and long-term lean transformation,Satoglu *et al.* (2018), emphasise the need of having a clear vision and goal that top management should support, as well as full employee participation. Employee empowerment should be made a prerequisite in this transition since it may boost performance, particularly when management acts as a facilitator (Lee *et al.,* 2022).

According to Kamble *et al.* (2020), the biggest hindrance to lean is the employee mindset. The lean approach is more hindered by employee resistance than by financial limitations or cultural differences. Shah *et al.* (2021), claim that despite a lack of, or insufficient employee training, lean may be implemented by raising worker attitudes and values. Since everyone has their own goals and will, the great number of problems is probably due to the difficulty of altering a culture. Bhasin (2012), asserts that from the start, should be clear about why the business is adopting lean and how people will benefit from it. Employees who fear infringements and job losses may sabotage the process, slowing it down, rather than those who recognise that change is in their best interests (Losonci *et al.,* 2011).

Arlbjørn *et al.* (2013), assert that opposition to a significant change in a firm is nearly always the case. While some workers may embrace a bleak view, others will fear losing their hard-won position in the company or even their job. As a result, many organisations and consultants are concerned that the company may acquire an unfair advantage by implementing lean methods. However, it is not a good idea to cite lean as a justification for downsizing since "respect for people" is a tenet of the production system (Marley & Ward, 2013). When workers at all levels participate in the decision-making and information-sharing processes associated with lean implementation, trust is increased (Deflorin & Scherrer-Rathje, 2013). When everyone is engaged and information openness is utilised to stop rumours, consistent messaging is a crucial element of lean success.

2.8.2 Lack of organisational culture

One of the most typical lean criticisms is the issue of organisational culture. The problem has been documented in the literature for decades (Bicheno & Holweg, 2016). Everyone in the firm shares a set of common values, beliefs, and assumptions. Organisational culture has an impact on individual behavior, which in turn has an impact on performance. When a company waits for "physical implementation" before addressing culture change, the problem arises. Culture and management issues must be addressed before true lean implementation can occur. It is vital to address organisational culture during lean deployment (Bhasin, 2013). More than just optimising the production process, lean also demands a cultural revolution.

A change in business culture, practices, processes, and leadership is required. Lean is widely applied in a range of sectors all over the world. In terms of organisational and national culture, each of these regions is distinct; as a result, to execute a successful lean system, each region must have the correct combination of both organisational and lean culture. During the lean shift, cultural differences may cause misunderstandings. Organisational culture and national culture must be kept separate in lean transformation, according to Wong *et al.* (2017).

According to Dorval, Jobin and Benomar (2019), two fundamental ideas in the lean philosophy—respect for respondents and continual improvement—define culture. Respect for respondents is the idea that a company's workers are its most valuable asset. Liker (2008), defined Toyota's culture as the way its workers behave and think daily. This has developed into a second personality for many Toyota employees who have worked there for years.

Businesses typically have a blame culture where management is always seeking someone to blame for an error or issue. The deployment of lean is suffering because of this blame culture. According to Dora *et al.* (2022), no employee that disclose faults or mistakes because they are afraid of being blamed. According to Angelis *et al. (*2011), "if the culture changes from who is to blame to emphasis what the issue is that caused the failure in the first place, respondents will be more willing to reveal errors.” Shook (2010), observed that American trainees in Japan often responded: “The ability to concentrate on solving issues without pointing fingers and searching for someone to blame,” when asked what they most desired to bring back with them. Only a positive and productive culture can provide the environment necessary for lean implementation to succeed.

According to Akmal, Foote, Podgorodnichenko, Greatbanks and Gauld (2022), a further element that may compromise the success of a lean deployment and any related processes is organisational culture. As was previously said, implementing lean involves adjusting organisational practises to increase organisational effectiveness, efficiency, and client satisfaction Maru *et al.* (2018). The organisation needs increased productivity, decreased lead times and inventory, enhanced product quality, and efficiently manage the production process to do this. There must be constant improvement efforts at all levels of the organisation to have a well-established, healthy lean system. By adopting these ideas, the organisation can go forward in the pursuit of its goals. According to Wong *et al.* (2017), the key to successful adoption is the cultural adaption to lean. This suggests that to create a successful lean enterprise, a company must construct a trust-based organisational culture built on stakeholder cooperation and support, continuous improvement initiatives, and employee empowerment.

The organisation will develop its organisational culture and build trust if it allows all workers to participate in decision-making and provide recommendations.

It seems simple, but it's not. Creating organisational culture is one of the most difficult tasks in adaptation of lean, according to Al-Najem (2014). According to Dorval, Jobin, and Benomar (2019), organisations are social structures with divergent interests that cooperate to achieve strategic goals. A cultural transformation improves organisation-wide performance. This alteration affects the system's behavioural, emotional, and political structures, per King and King (2017). Employees of a company that does not adopt lean revert to old practises, reversing the benefits of lean adaptation. The company's lean efforts are doomed. According to Maru *et al.* (2018), adopting lean ideas is more challenging in some sectors and nations due to social-cultural differences and how business is done there, making organisational culture transformation difficult. Country culture can impact employee attitudes and behaviour more than organisational culture.

In lean transformation, national and organisational cultures cannot be separated. Lean businesses promote respect and long-term thinking. This requires respecting a person's developmental stage. Some cultures find this strange. All businesses trying lean must overcome this hurdle (Dorval *et al.,* 2019).

There are seven sorts of impediments, with knowledge and support barriers being the most difficult to overcome. Examples include resistance to change, intangibility and uncertainty of results, poor presentation of LSS results, lack of top management support, and unsupported organisational structures (Aboelmaged, 2011). Higher education is less LSS-friendly than others. According to Antony *et al. (*2012), LSS terminology intended for manufacturing doesn't function in Higher Education (HE), and the idea that LSS produces fast outcomes may be false or overblown. Higher education institutions (HEIs) may not promote LSS implementation due to a lack of knowledge of their various customers, including students, professors, and administrative staff. According to Antony *et al. (*2016), the major challenges to LSS applications include failing to link LSS project goals to clients and the organisation's larger aim and running out of money and time.

A successful deployment demands that lean be accepted culturally throughout the organisation (Wong *et al.,* 2017). The organisational culture must be built on worker empowerment, cooperation, and support from stakeholders to develop a successful lean corporation. Including all workers in decision-making, implies a dedication to ongoing improvement. To foster a positive work environment for all workers, regardless of status, stakeholders should be involved in communications. This is because they are partners in this lean organisation.

2.8.3 Lack of stakeholder commitment

Wong *et al.* (2017), asserts that the execution of the lean process is critically dependent on receiving most of the support from the organisation's key stakeholders. Stakeholder involvement is essential to many firms in all that the industry do. Most firms are unable to incur significant expenditures without the approval of their stakeholders, particularly when the funds aren't directly tied to consumers. When the restructuring process and the idea of lean are not successfully conveyed to stakeholders, it might be thought to be too risky to undertake (Alyousef, 2019). Because of this, the organisation's management needs to explain the principles and methods of lean and how it will benefit the business to enable key stakeholders to embrace the deployment of lean. All organisational levels, including stakeholders, must be committed to and supportive of the lean initiative for it to be effective. Furthermore, the effectiveness of the lean system depends on effective stakeholder communication. This entails alerting them of the implementation's accomplishments and positive results. Due to stakeholder support and buy-in, as well as guarantees from the organisation's staff regarding future work plans, resistance to lean adoption has diminished (Bhasin, 2012).

Employees need to be committed to implementing lean, as well as acquire the necessary training to do their jobs in the new lean environment. A major barrier to success is inadequate supervisory capabilities to adopt lean due to a lack of training (Bhasin, 2012). Additionally, the study by Starbird and examples include resistance to change, intangibility and uncertainty of results, poor presentation of LSS results, lack of top management support, and unsupported organisational structures (Aboelmaged, 2011).

Implementing lean demands a shift in how work is approached in a manufacturing setting (Sahoo, 2020). Redesigning incentives and bonus programmes should be a part of it to encourage efficient use of time, money, and resources. This requires buy-in from senior executives to machine operators as official job descriptions are blurred as a result of fewer people being needed to carry out a larger variety of work duties. All stakeholders must completely commit to the implementation of lean manufacturing processes, that is, reducing waste honestly. Training is essential in all these areas.

According to Singh *et al.* (2021), technical training is a crucial component of lean manufacturing and may need an initial investment in new technology and production equipment or statistical analytic tools for tracking quality improvement on assembly lines. The right systems must be in place to succeed as the organisation will be dependent on it for a continuous, successful operation. Automating as a lean business strategy makes a company much more technology-dependent (Leke & Marwala 2019).

2.8.4 Lack of communication within the organisation

The challenges are made worse by the ineffective communication between staff and senior management (Jadhav *et al.,* 2022). Shah *et al.* (2022), stress the significance of context in the adoption of lean. Some challenges are unique to each nation. Machado *et al.* (2022) noted a hierarchical organisational structure in China, which may hinder lean projects. Leyer *et al.* (2021), also emphasises the need for supervision in ensuring that employees get the proper instruction and training. According to Kotter (2017), to convince lower-level workers to participate in the lean transformation, senior management involvement is required. The change should have the support of senior management as well as the necessary funding. Top management must also commit and provide the required assistance, both physically and intellectually. Employee perceptions of the leaders might be harmed by top management's complacent attitude toward lean (Emiliani, 2008). Al-Najem (2014), claims that successful or poor communication within the company is a further variable that could affect the adoption of lean.

Even though many businesses claim to have strong departmental of communication, misunderstandings may undermine attempts to embrace lean. Improved communication is one of the primary advantages of implementing lean successfully. On the other hand, if there is no communication, work quality and output may both suffer. According to Jadhav *et al. (*2022), a lack of passion and determination may also lead to other difficulties such as restricted access to resources, sluggish decision-making, and communication issues. Another problem mentioned by senior management is a lack of managerial competence. The need for "blue collar" engagement in information flow is emphasised by Emiliani (2015), to make the best judgments feasible regarding responsibility. A leader's aptitude affects the effectiveness of lean techniques (McLean *et al.,* 2017).

One of the main advantages of correctly and effectively adopting lean is increased communication. Conversely, when there is a communication breakdown, both the output and the quality of the job decrease. Miscommunication during shift changes in a company with frequent shift changes may also cause resentment (Al-Najem, 2014). The communication process helps individuals accept the new lean idea and overcome employee resistance to new changes in their job. Lean adoption requires major change, and change may be difficult for those used to doing things a particular way. Top management through lower levels must comprehend lean ideas, methodologies, and the implementation process for lean to be successfully implemented.

Excellent communication is essential for lean implementation success. Excellent communication ensures that all workers at all organisational levels accept and implement lean improvements, avoiding failure (Yuik & Puvanasvaran, 2020). Clients and vendors need clear communication. Internal customer-supplier contacts must have a clear procedure for communicating and receiving concerns.

2.9 Application of Define Measure Analyse Improve Control in order processing

Define, Measure, Analyse, Improve, and Control (DMAIC), is a problem-solving technique used to identify the sources of variation in system processes (Chang, 2016). DMAIC Cycle Definition measures initial and target performance of a process, analyses process data to determine key process inputs that affect outputs, enhances processes to optimise outputs, and identifies enhanced process Control is an enhanced process that keeps improving (Foster *et al.,* 2014). The Six Sigma team uses advanced root cause analysis techniques and statistical tools throughout the DMAIC cycle to drive continuous improvement.

The relationship between Six Sigma and Lean principles for process improvement aims to eliminate sources of process variation without affecting the underlying process (Tohidi *et al.,* 2012). This is called process improvement. In Six Sigma terminology, process improvement teams identify critical Xs (causes) that lead to undesirable Ys (defects) created by the process. 5S is a collection of techniques for systematically improving workflows, practices and products by supporting visual control and lean implementation. The key to execution is the employee. This is the foundation for continuous improvement, zero defects, cost savings and a safe working environment. These phases logically guide the team from defining the problem to implementing solutions related to root causes and establishing best practices for maintaining the solutions.

2.9.1 Six-sigma strategy

DMAIC is a closed-loop process that leverages technology to continuously improve, removes ineffective phases, and often focuses on new measures. By putting this plan into action, management will enhance order processing systems right now. Six Sigma is a data-driven systematic methodology using the Define, Measure, Analyse, Improve and Control (DMAIC) process and the Design of Six Sigma Methodology (DFSS) (Kumar *et al*., 2015).

It often pertains to problems with order processing and manufacturing, among other difficulties. A "business strategy used to increase company profitability, to improve the efficacy and efficiency of all activities to meet or surpass customer wants and expectations" is how six sigma is described in the business sector (Talankar, Verma & Seth, 2015). The six sigma technique was swiftly extended to several functional areas including marketing, engineering, buying, service, and administrative support as companies understood its advantages.

2.9.2 Phases of Define Measure Analyse Improve Control

2.9.2.1 The Define phase

The DMAIC processes define phase comprises defining the team's responsibilities, the project's boundaries and scope, Customer needs and expectations and selected project goals (Bhat, Gijo and Jnanesh, 2014). The agreement stipulates that the manufacturing organisation's senior management must specify the goals and parameters of the team. Top management must communicate to the team "what the project is and what it should achieve" to ascertain the demands of the consumers. Specifically, the aim and length of the project must be examined at the define phase. The define phase must validate comprehension: the group and management ought to identify the problems that influence patients the most, the primary variables influencing the voice of the customer (VOC), and the extent to which the present performance satisfies patients' needs for satisfaction (Rahmadi & Bernik, 2018).

The issues are crucial for in-service organisations. The starting and finishing points on the project map are often used by the organisation to set boundaries when building a process map. However, if respondents's concerns are not identified, these LSS mapping procedures will fail. Two-person problems must be defined at the define phase, for example. The presence of the required team members must be ensured by the project manager

- Team members should be assessed on its attitude and performance in addition to the knowledge, experience, and training the members obtain.
- The project manager must make sure that everyone in the team is contributing equally to the project operations. It will be simpler to accomplish the project the more team members actively engage in it and appreciate its importance.

2.9.2.2 The Measure phase

Kumar, Singh, Bhamu (2021), asserts that operational process definition is essential to the quality and that it is utilised to establish the quantifiable service indicators in Medium Scale Integration (MSI) stage . Additionally, at this stage, input and output measures are identified. Examples include collecting data at the process level. Create a base index; organise sequence data logically into a visual representation and maintain statistical rigor through sampling and reporting. After identifying Volatile Organic

Compound (VOC), the measurement transforms client input into quantifiable design needs. The focus on VOC may be unfamiliar to respondents who are used to DMAIC initiatives. A solid grasp of client demands is stressed as a crucial success element in VOC analysis, even if customer needs influence the priority of the DMAIC project. The team should carry out the following Value Stream Mapping (VSM) measures to interpret the VOC:

- A data collection plan.
- Map of the present and future conditions.
- Figure out what MSI needs.
- Characterise the factors that potentially lead to the quality problem under discussion using histograms.
- Use search with variables.

The employees have to utilise scatter plots; response surface methods; Pareto charts; measurement check sheets, or other visualisation techniques to draw attention to the crucial few sources of the order processing problems. Unfortunately, a lot of individuals have been seen in service organisations manipulating data and figures to support untrue claims. Managers must collect and process data, in order to contact the team to identify what information to obtain, why, and how it will be used to evaluate client needs (Gupta *et al.,* 2020).

2.9.2.3 The Analyse Phase

The analyse phase evaluates the data obtained and uses VSM to identify and corroborate the primary reasons for NVA method failures (Gholami, Jamil, Mat Saman, Streimikiene, Sharif and Zakuan, 2021). This phase examines the data collected during the measurement phase to identify sources of waste, delays, and poor quality. Map and investigate causality using Pareto charts, causality plots, scatterplots, design of experiments, and five "why" analyses, as part of the LSS process. The LSS team recognises service process disruptions and assesses customer value-add or NVA work. Three groups may be created from the value process:

- Customer Value Added (CVA): CVA exclusively takes customers' worth into account.

- Business Value Added (BVA): Although this category is advantageous to companies, it offers nothing to consumers.
- Non-Value Added (NVA): This is a worthless activity for the customer. In most service operations, tasks such as phone calls, forms, and inquiries occupy only 5% of his time. After Ng *et al.* (2014) 95% is used for waiting, planning, rescheduling, reworking, and other activities. When an organisation increases value added work by 20%, NVA work is reduced by 20% to 50% and project spending is reduced by 20% to 50%. A trained manager leads the team through VSM events to reveal the customer's added value and NVA work procedures, as well as identify faults in service operations.

2.9.2.4 The Improve phase

According to Smętkowska and Mrugalska (2018), the LSS project team removes the root cause of errors that negatively impacted the CTQ process at this stage. More importantly, the improve phase transforms service operations by eliminating the inefficiencies, waste and costs associated with customer needs in the define phase. During this phase, traditional methods and strategies are used to find the best solution to meet the customer's needs. Associated with brainstorming ideas, project goals, and techniques for meeting customer needs, teams should use the Solution Matrix tool to select the best opportunities.The project manager should pay close attention to the implementation methods, which include:

- Review planning and scheduling activities regularly and immediately halt anything that goes wrong.
- To identify the cause of a problem and how to resolve it, in order to avoid delays or interruptions in improving the order process.
- Create a plan to fix quality issues. Create a strategy for covertly reducing restrictions and enhancing driving variables.

However, nothing will change because of the enhancement. A representative sample of the larger group of respondents participating in the process might be drawn from the team members. Clear and frequent communication with colleagues might facilitate their work and help them achieve their goals. They could talk about other options, provide helpful criticism of their co-workers' work, and ask for help. The idea of kaizen may be used to assign tasks and evaluate how effectively the tasks are accomplished. It supports productive cooperation and proactive communication for better job performance (Sharma, Malik, Gupta & Jha, 2018).

2.9.2.5 The Control phase

The control phase's objective, according to Gholami *et al.* (2021), is to identify long-term fixes. To do this, an individual must monitor the effectiveness of the LSS process, as well as enhance and control the variables that are essential to process performance. The project team must ensure that everyone is using the same procedures by sharing the individuals' expertise with those who will take over the roles. The team must adhere to six main control issues in the service environment to improve process performance.

Costa *et al.* (2017) indicated that it is important to make sure the improvement process is written down:

- Transform the earnings into money (as verified by the finance division).
- Verify sure advancements are kept up throughout the working procedure.
- Install an automatic monitoring system to spot performance that is "out of control."
- The work procedure should be well-organised.
- Create a control plan (Costa *et al*., 2017).

According to Carreira and Trundle (2011), a control process plan defines who oversees what in a new process. This is typically built on a process map of future states. Therefore, the LSS team should consider the root causes of potential problems that may arise when resolving quality issues, and it is not possible to use control charts to track changes in potential problems. Beneficial.The team must use the control chart in addition to observing statistically significant variations to carry out the control plan. Service providers should also be trained on how to effectively use an integrated quality control (QC) system and delegate decision-making authority throughout the service process (Scala, Ponsiglione, Loperto, Della Vecchia, Borrelli, Russo, Triassi & Improta, 2021).

2.10 Conclusion

LSS is commonly recognised as a crucial facilitator of industrial competitiveness in terms of process efficiency and improvements. For a manufacturing company to perform above average, its order processing procedures and efficiency must be improved. The company's entire production strategy should be used to help incorporate this aim. According to the method, it looks that DMAIC might be a useful tactic for enhancing order processing and getting rid of any delays that can cause the business to lose clients and damage its image.

This chapter provided a justification for the current study by placing it in context in terms of the extant literature. The next chapter describes the research methodology used in this study. This is in line with the research question posed in Chapter 1.

CHAPTER 3: RESEARCH METHODOLOGY

3.1 Introduction

Techniques and procedures employed to gather, modify and evaluate the obtained data are covered in this chapter. The chapter also highlights sampling strategies and methods for calculating sample size. The chapter ends by describing the methods that were used to improve the reliability of the results. A well-planned methodology outlines the logical order of steps, activities, and processes a researcher wants to use to gather and evaluate research data before starting a research project.

Two key issues are addressed by the research methodology:

How was the data gathered or produced? And secondly, how was it examined? A methodology, then, offers a blueprint or systematic route that directs the whole research process or activity. In a perfect research environment, a methodology would establish the whole study's theoretical and philosophical direction. Therefore, a methodology serves as the cornerstone around which research is built.

Depending on the kind of research goals being pursued, a research technique is affected by either an interpretivist paradigm or a positivist paradigm. The technique that was utilised to perform the research often has an impact on its findings. A methodology shows a step-by-step procedure the researcher has in mind for gathering and analysing study data in addition to establishing the research idea.

3.2 Research design and Approach

This research used quantitative study methods. Mohajan (2020) considers quantitative research to be a formal and objective (i.e., subject to the researcher's ideas and values) to find and analyse correlations and explore the causes and effects of interactions between variables. unbiased) as a rigorous strategy. Ingham-Broomfield (2014), defined quantitative research as "a survey to acquire information from a sample of respondents through self-report, in which the participants respond to a sequence of questions presented by the researcher." According to Liu *et al.* (2018), there are three basic approaches to conducting quantitative research: surveying individuals, conducting interviews, and executing experiments. Data for this study were collected via a standardised questionnaire distributed by the researchers to the respondents.

Because it accurately captures behaviour, perspectives, abilities, beliefs, and knowledge, a descriptive survey was chosen (Burns & Grove, 2014). Utilising this method, researchers looked at how LSS affected order fulfilment in South African manufacturing firms; determined the important variables influencing order fulfilment in South African manufacturing firms; examined the advantages of using LSS in the industrial environment; determined the difficulties related to LSS in the manufacturing sector to provide suggestions for enhancing order fulfilment in manufacturing firms.

3.3 Qualitative research approach

The registered Cape Peninsula University of Technology (CPUT) assisted with the data being analysed on completion of data collection using Statistical Pakages for Social Sciences (SPSS vervsion 28).

According to Cropley (2019), qualitative methods differ from qualitative methods in the interaction between researcher and research subject. In qualitative research, all parties participate in a collaborative knowledge of generation process Quantitative approaches aim to explain things, while qualitative approaches try to make sense of them. Qualitative research sheds light on respondents's perceptions, understanding, and interpretation of the world in their daily experiences. They tend to be micro-analytical and often (but not always) focus on specific problems in specific situations (Hedlund-deWitt, 2013).

Quantitative research, on the other hand, focuses on discovering new general rules of behavior or expanding our knowledge of known regularities. Usually (but not always) ethical and macro-analytical. Three aspects of a qualitative approach can be understood: an ontology (i.e. how reality is perceived), its epistemology (i.e. the types of questions that are considered relevant), and methodology (i.e. i.e. the steps necessary to get the answer there) (Van den Berg & Struwig, 2018).

Ontology: This research method states that each person actively “builds”his own “reality” from his own experiences, and that this reality varies from person to person, “socially it assumes that you have created a "reality" of ". (Anderson, 2017).

- Epistemology: Qualitative methods place a strong emphasis on queries like:
  a. Respondents interpret their surroundings.
  b. Describe how they comprehend.
  c. How do the respondents choose to act in the own reality? How does respondents explain what individuals have learned from others? (Steward, 2015).

- Research Approach: Social science as an empirical field relies on observation of human behaviour to gain knowledge. This distinguishes adhering to the principles of a self-consistent, self-contained set of axioms accepted as indisputable truth (such as Marxism, religion, etc.) or using rationale behind (mathematics, philosophy, etc.) is distinguished from the non-empirical field of knowledge processing by. Both qualitative and quantitative research methods use behavioural observations as a new source of information (Silverman, 2013).

3.4 Quantitative research approach

According to Ying *et al.* (2017), quantitative methods emphasise statistical data, complex mathematical methods involving probability theory, and large-scale machine computing, whereas quantitative studies require researchers to look under the microscope at Examine an object (usually called a "subject") (i.e. a computer). In this way, the qualitative approach is more "human". These include trusting interpersonal relationships, committed teamwork, and more. Technical design criteria are often less stringent with a qualitative approach.

These may be disregarded or at the very least considered "flexibly." Comparatively, quantitative research starts with a corpus of knowledge that already contains generalisations and explanations, i.e., hypotheses regarding correlations between occurrences. An example is research based on the knowledge that exposure to linguistically stimulating environments promotes the development of intellect. A typical quantitative study identifies techniques to measure intelligence (IQ score) and levels of exposure to rich language environments such as B. Length of Formal Education to Measure. In post-design, you can create two groups: one with formal education (experimental group) and one with less-formal education (control group). A research hypothesis is considered validated if there was a statistically significant difference in mean IQ between groups (Bryman, 2017).

3.5 The relationship between qantitative and qualitative methods

Quantitative methods nearly usually incorporate numerical data, which is often gathered through mechanical or electronic equipment, questionnaires, psychological exams, or any mix of these. They are also often linked to formal hypotheses and the testing of such hypotheses (i.e., deductive reasoning), particularly when analytical statistics are used. Comparatively, qualitative approaches are closely related to the collecting of verbal data through techniques like interviews.

The most common methods for data analysis are variations of content analysis, and typically are carried out without assumptions, at least in the first phases (Yousefi Nooraie, Sale, Marin & Ross, 2020). In qualitative designs, identifying hypotheses rather than testing them may be the primary goal rather than drawing conclusions since statistical analysis is very seldom used. As a result, there is a connection between the study methodology and the informational content. This fact is especially relevant to research using "mixed" models (Tashakkori & Teddlie, 2010), which aims to blend the two types of information provided by the various methodologies to have a greater understanding of the phenomena being studied (Maxwell, 2019).

3.6 Area of research

The current research was conducted in the Gauteng of South Africa. Those who responded included operations managers, supply chain experts, procurement officials, consultants, and financial analysts. Because consumers are the most important client and are the ones who face the effects of unfulfilled orders, the study concentrated on the real procedures and the viewpoint of the customer.

3.7 Target population

The population consists of respondents who meet the criteria for inclusion in the sample and who have characteristics of interest to the researcher (Fellows & Liu, 2018). The respondents or groups that the survey is intended for make up the target population. However, the phrase may also refer to organisations or respondents who can answer the questions for the survey and to whom the findings are applicable.

The study's target audience included operations managers, supply chain experts, procurement officials, consultants, and financial analysts, who are registered with different professional organisations in other parts of Southern Africa. One thousand seven hundred (1700) people work at the two Johannesburg firms collectively. A group of three hundred (300) individuals with diverse roles including operations managers, supply chain experts, procurement officials, consultants, and financial analysts possess the essential LSS expertise and a comprehensive understanding of the order fulfillment process. Therefore, this cohort of 300 individuals has been chosen as the study's sample. Standardised questionnaires were sent to respondents who work in SA's manufacturing industry. For the research to accurately depict the effect of LSS on order fulfilment in manufacturing businesses in Gauteng, South Africa, this criterion was judged as important.

3.8 Sample

In social research, sampling techniques typically fall into two main categories, namely, probabilistic sampling and objective sampling. Probabilistic sampling methods are commonly used in quantitative research (Teddlie & Yu, 2017). For this study, the researcher opted for random sampling instead of stratified sampling, cluster sampling, or other probability-based sampling methods. A random sample was used because each participant had an equal chance of being selected and all individuals who met the requirement to be manufacturing professionals working in South Africa were selected. The conditions for every participant of the target population to have equal performance or qualities, or for a sufficiently large sample size to ensure accurate representation and equal chance of selection for all potential respondents. Three hundred workers (300) were chosen as the sample from among those knowing LSS based on the target audience. This comprises managers of operations, experts in the supply chain, those in charge of procurement, consultants, and financial analysts.

3.9 Data collection

A questionnaire was employed in this study to acquire data because it allowed the researcher to have a full understanding of the respondents who replied as it allowed enough time and space to respond and provide the respondents' views. Additionally, this research method allowed researchers to collect data remotely. Accessing respondents in Gauteng Province would have been difficult for the researcher given the travel and other limits placed on people due to Covid-19 in South Africa at the time. The concerns or difficulties identified by the literature were considered while creating the questionnaire. Out of three hundred (300) participants, one hundred and fifty eight (158) workers answered the questionnaire. The workers were well versed in LSS requirements and the order fulfilment procedure.

3.10 Research instrument

Pekeur (2002), stated the aim of research methodology as the analysis of the dimensional nature that evaluates the purpose and its objectiveness of the study. Therefore, the adoption of primary data collection for the study to use online questionnaire as the research methodology for this investigation was necessary due to large- scale sample size survey design in which an extensive data to be collected from the participants. The questionnaire design employed a five-point likert scale aligned with the studys objectives.

Burns (2019) claim that although the questions in a questionnaire are frequently shorter than those in an interview, the data obtained this way is equivalent to that obtained through an interview. To evaluate the effects of LSS and methods for minimising delays in the order fulfilment process, information was gathered using a questionnaire. Questionnaires come in two varieties: Close and open. Open-ended surveys encourage respondents to provide written responses in the respondents' own words and to provide as much information as necessary. This differs from closed-form questions, which present respondents with predetermined choices relevant to the topic selected by the researcher (Burns, 2019). An open-ended questionnaire was not employed in this study because the complications of analysing the data interpretation from the respondents' critical thinking would result in richness of respondents' feedback unique way, its diversity and difficulty in comparison to the study.

All the respondents were educated professionals in the manufacturing field; thus the questionnaires were written in English. The confidentiality of the respondents' replies was guaranteed. The questionnaire comprised three sections. In Section A, biographical information was sought, including gender, age, education, roles held, tenure in a certain position within the organisation, etc. This knowledge would be useful to the researcher when evaluating the findings from Section B, which focused on order processing delays, and Section C, which focused on Lean Six Sigma performance indicators.

With reference to the identified criteria from the examined literature, a five-point Likert scale was utilised to assess the impact of LSS on the order fulfilment process in the South African manufacturing sector.

In this study, a 1 to 5 scale was employed, ranging from "Strongly Disagree" to "Strongly Agree", to measure the variables of interest.

To help respondents with the responses, instructions and guidelines were linked to the surveys. The total number of questionnaires returned was 158 usable questionnaires which constitute an 53% response rate. Based on the claim made by Fadason, Danladi and Akut (2018) If the response rate is less than thirty-fourty percent, the survey results may be considered biased and of low value, this was deemed sufficient for the study.

3.11 Data analysis

Following data collection and data analysis, data were presented as frequency distributions and the percentages. The data were displayed in tables, bar graphs, and pie chart diagrams after frequency tables were created. Statements on the factors under investigation were included in the questionnaire. Some statements elicited responses on a five-point Likert scale, with 1 denoting strong disagreement, 2 disagreement, 3 uncertainty, 4 agreement, and 5 strong agreement. The respondents' completed questionnaires were gathered, and before further processing, the questionaires were examined to make sure that the data could be used. Since the quantitative statistics is already pre-coded by listing various number codes against various replies, it was necessary to convert the textual data to a numerical format before entering it into Statistical Package for the Social Science (SPSS) Version 28 for analysis using the appropriate statistical procedures. Additionally, a 5-point Likert scale was utilised to examine the advantages of Lean Six Sigma methods in the manufacturing sector concerning the criteria found in the extant literature. The chosen scale also included the following values: 1 for strongly disagreeing, 2 for disagreeing, 3 for not sure, 4 for agreeing, and 5 for strongly agreeing. Each factor's mean item score (MIS), as determined by the respondents, was converted from the five-point scale. The rankings of each item were then established using the indices, as was previously stated. The criteria are then sorted according to their relative relevance index in decreasing order after the mathematical calculations. The survey's results are presented next.

3.11.1 Statistical Package for the Social Science (SPSS)

The advantage of using SPSS version 28 is the ability to perform new statistical procedure (meta analysis) to improve the current procedures that exist such as Power Analysis to elevate the methodologies of research, conceptualisation of data for better understanding of connections, as well as the functionalities to improve the daily usage that is designed for data analysis, (Borenstein, Hedges, Higgins, Rothstein, 2021).

SPSS, is a social phenomena data analysis computer application that was used to examine the collected quantitative data. This program was used to generate various statistical outputs, including descriptive statistics, which provide the underlying distribution of all variables in the data (Henn *et al.,* 2006). The advantage of collecting data correctly from surveys items from the fact that the accuracy of results are highly dependent on input.

3.11.2 Mean Item Score (MIS)

The data gathered from the questionnaire survey were analysed using this approach. The sum of all weighted replies was used to compute the mean, which was then compared to the total responses on each facet. This was done under the assumption that is empirically discovered measure of relative significance was the respondents' total score for all specified criteria. Totally disagree to totally agree, "Never" to "Always," and other comments received a weighting ranging from one to five. Below is a mathematical representation of this. The following mean item score (MIS) was calculated as such:

$$MEAN = (1n1 + 2n2 + 3n3 + 4n4 + 5n5) / \sum N$$

The following represents:

n1 = Extremely Unlikely or Strongly Disagree number of respondents

n2 = Unlikely of Disagree in total number of respondents.

n3 = Neutral in total number of respondents.

n4 = Llikely or Agree total number of respondents.

n5 = Extremely Likely or Strongly Agree total number of respondents.

N = number of respondents in total.

Conditions are ranked in descending order of mean score (highest to lowest) using a mathematical calculation. The researcher gathered the data during November 2021 and January 2022.. The data was displayed in tables, bar graphs, and pie chart diagrams after frequency tables were created.

3.12 Vallidity and reliability

Validity and reliability are effective techniques that are used in lean manufacturing for its effectiveness in ensuring the accuracy and its measures of astudy. It is about how well a reseach study measures to what is intended to measure. To ensure that the research is all- encompassing and based on solid ground. Validity is about the relevance, appropriateness, and correctness of the interferences the researcher makes from the data. There are several types of validity. Subsequently,Reliability refers to the consistency or repeated measure in a research study. The stability of the data and whether the results can be replicated under similar conditions. High reliability indicates that a measure produces consistent results over time.

3.12.1 Validity

Validity can be performed in four different ways in order to obtain several objectives of a study, in general, these types of validity analyses that can be performed are content validity, predictive validity, concurrent validity, and construct validity such as:

- Content validity –decision made by the high level of expertise to test the measurements of a study using a qualitative method only.
- Criterion related validity - is the determination of the same process to compare both processes to be confirmed valid. The correlation between the validity to test the measure of an outcome.
- Construct validity – is an assessment measure to assess the extent of the relevance of validity data.

To perfume an effective validity, firstly the relations between elements which represent the validity hypothetically. Secondly, the development to measure a tool that involves elements to effectively represent the constructs. Thirdly, the collection of empirical data of the study must be conducted in order the thorough hypothesis relations to be examined. Lastly, the consistency to determine the hypothesis of data (Jasti *et al.,* 2014). Muijs (2004) and other researchers have alluded in their investigation that validity analysis has several characteristics that have been proposed which including content validity, criteria-based validity, and construct validity. Among these three validity analyses of criterion-related validity, these two; current validity and predictive validity are represented.

3.12.2 Reliability

Reliability is the consistency or accuracy with which an instrument measures the property it is designed to measure (Elliott, Knodt, Ireland, Morris, Poulton, Ramrakha, Sison, Moffitt, Caspi, and Hariri, 2020). Reliability of a study and its results means that the same study can be repeated with the same results. A scale's resilience to accidental errors is determined by its reliability.Test-retest reliability and internal consistency are two often used measures of scale reliability. However, it serves to be mindful of internal coherence. Internal consistency, or how closely the scale's components cluster, measures how well each component measures the same underlying characteristic (Brandão *et al.,* 2015).

According to Jasti and Kodali, (2014) stated that the extent of reliability consistency is measured by the probability of a variable or set of variables. To calculate the reliability of any set of variables an industry can use these four methodologies such as; test- retest reliability, alternate forms of reliability, split-half reliability and internal consistency approach for an application. The performance of the analysis in manufacturing industries is to determine distinctive frameworks in India. In general, to determine the framework of reliability an inter-item analysis can be used.

3.13 Consideration of ethics

As an ethical factor, this study looked at the responsibilities to the professionals in the field whose work was used in the literature and was correctly cited and acknowledged. Participants in the study questionnaire were obligated to keep their responses private and to use the responses exclusively for educational reasons. Survey respondents had the opportunity to refuse to answer any questions the respondents believed were inappropriate. The Department of Business Administration at Cape Peninsula University of Technology (CPUT) provided a formal cover letter granting permission to conduct this research project, which was attached to the questionnaires that were distributed.

According to Martin (2014) Therefore, throughout the whole research, confidentiality and anonymity were maintained. When respondents are anonymous, not even the researcher can connect to specific replies (Burns & Burns, 2008). During the research process, the researcher ensured that there was no harm to aprticipants. The sampling design of the study that is used is a multi-center study. The main experimental procudures to participants were defined in detail, and the participants were fully informed about research expectations. It was stated that the participation of respondents was voluntary. The researcher requested a written consent of participation from the respondents and explained that there was no obligation to complete the questionnaire, a participant may decide to withdraw from the research at any given time.

Participants were informed that they may omit any question/s that one do not want to answer, as well as the collection of data will be handled with confidentiality. The researcher was provided with two consent letters see Appendix 1, from both manufacturing companies that were used for this study .

3.14 Conclusion

This chapter explains the study's research methodology, including sampling, collection and analysis of data, ethical standards, and the rationale for the use of questionnaires. In the next chapter, research findings and discussions of the data are presented.Based on the nature of the research this study has made use of quantitative research approach, which has been discussed in detail in the current chapter and followed by research data collection, research instruments, as well as data analysis. According to the nature of data, the SPSS v28 was used for analysis of data.

CHAPTER 4: DATA ANALYSIS

4.1 Introduction

This chapter presents the results of standardised questionnaires that were given to study participants, in the province of Gauteng, are presented in this chapter. Those who responded included operations managers, supply chain experts, procurement officials, consultants, and financial analysts. The questionnaire that formed the basis of this quantitative research was used to collect data for analysis and interpretation. The questionnaire consists of three categories: A, B, and C. The questionnaire was divided into three parts: part (A), which examined the respondents' backgrounds; part (B), which examined the advantages and delays of order processing; and part (C), which examined the LSS performance indicator.

4.2 Socio-demographical information of respondents

Three hundred questionnaires were administered to the study sample. Of the 300 disseminated, and 158 were usable.

4.3 Gender

Figure 4.1 illustrates the gender structure for this study. It showed that there were 48.10% (76) were males and 43.04% (68) were females. Since the all participants were invited voluntarily, there were 8.9% (14) participants refused to be classified. It was difficult to enforce these participants to complete this category. Hence, the researcher indicated these group of participants as “Unclassified”.

According to StatsSA (2022) mid year, the propotion of gender from the general population in the Gauteng is about 22.1% males and 3.9% females reside in the province. Apart from the “Unclassified” participants, the results of gender in this study is generally in line with the overall population as recorded in StatsSA (2022). This indicates that males are still dominating the overall population in the manufacturing industry in the province.

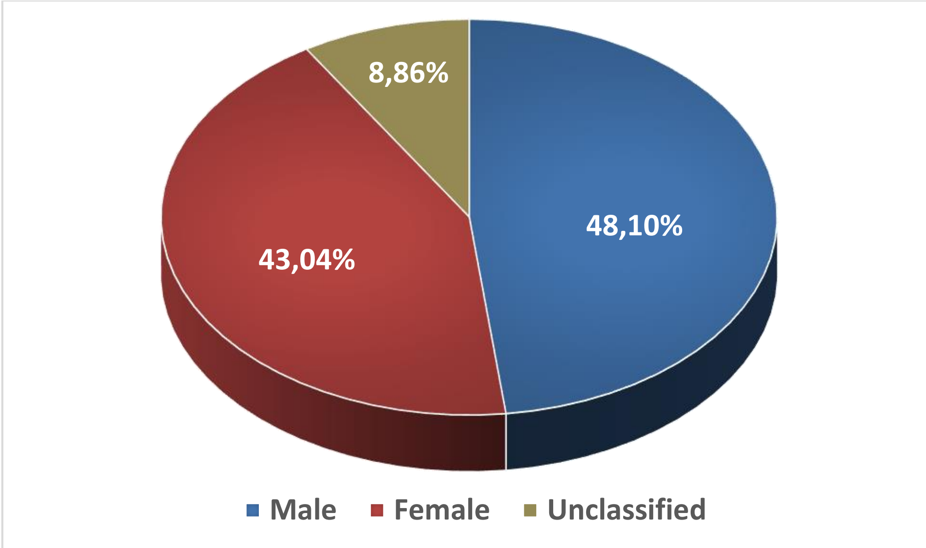

Figure 4.1: Gender

4.4 Age group of respondents

Regarding the respondents' age range, see Figure 4.2. The results show that 6.3% of respondents were in the age 20 years and younger, 15.8% were within the ages of 20 to 25 years, 17.7% belonged within the ages of 26 to 35 years, 26.6% were within the age range of 36 to 45 years, 24.7% were within the age range of 46 to 55 years, and only 8.9% fell in the age range of 56 years and older.

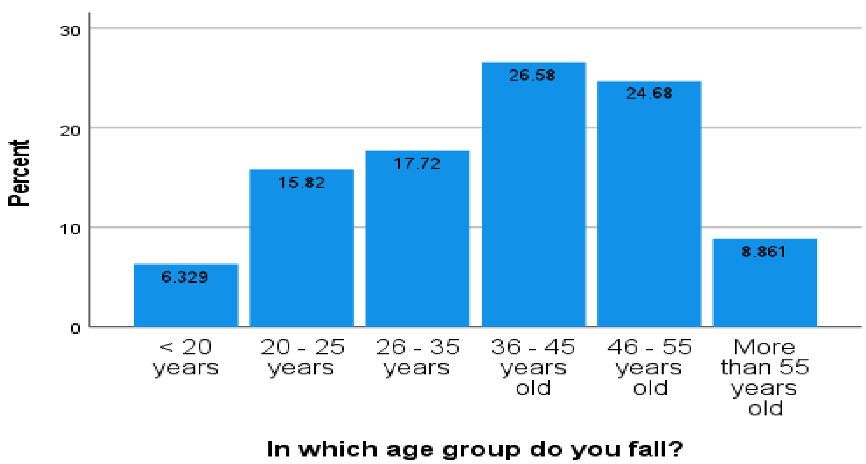

Figure 4.2: Respondents’ age group

4.5 Education qualification respondents' group

The examined sample's highest level of education shows in Figure 4.3. The results revealed that, of the 158 respondents, 8.2% had High school, and or no diploma, high school graduate (grade 12), 12.7%, 12.7% had diploma, 23.4% had bachelor's/ B-tech degrees, 38% had master's degrees, and 2.5% had Doctorate degrees, and 2.5% could not be classified.

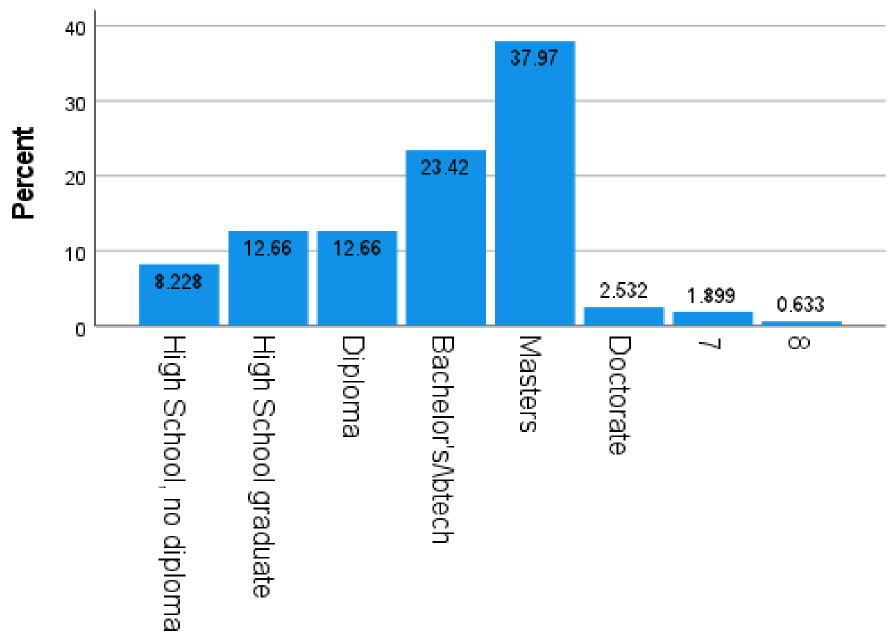

Figure 4.3: Respondents' education qualification

4.6 Ethnic group of respondents

The results for the ethnic group of the respondents are presented in Figure 4.4. The results show that of the estimated sample, thirty two percent (32%) were African (Black), twenty percent (20%) Coloured, sixteen (16%) White, and seven percent (7%) were between Indian and/or Asian.

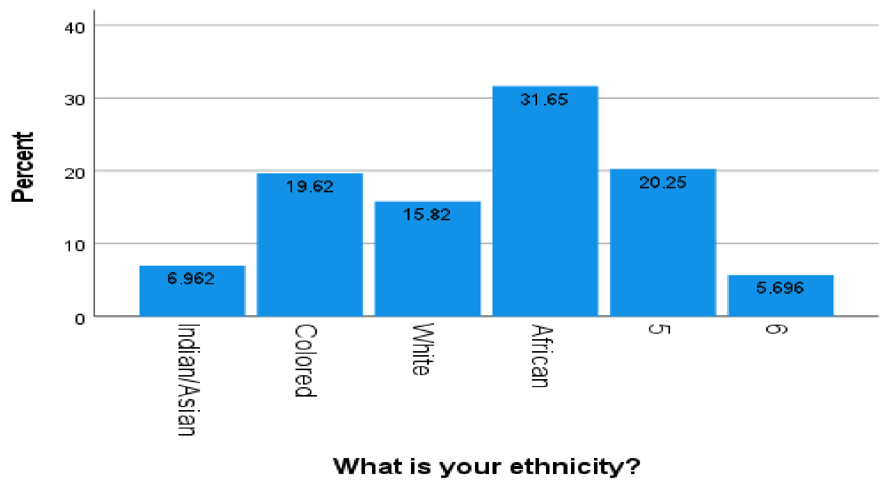

Figure 4.4: Respondent's ethnicity

4.7 Employee work experience group of respondents

The years of work experience in manufacturing sector are displayed in Figure 4.5. According to the results, 13.3% of the respondents had experience in the manufacturing sector for less than 5 years12% had experience in the 5 to 10 year range, 12.7% had experience within the range from 11 to 15 years, 19.6% had experience with an indication range from 16 to 20 years, and 34.2% had experience within the range from 21 to 25 years, 3.8% had experience with an indication range from 26 to 30 years, 2.5% had over 30 years of work experience, and 1.9% employees were not categorised.

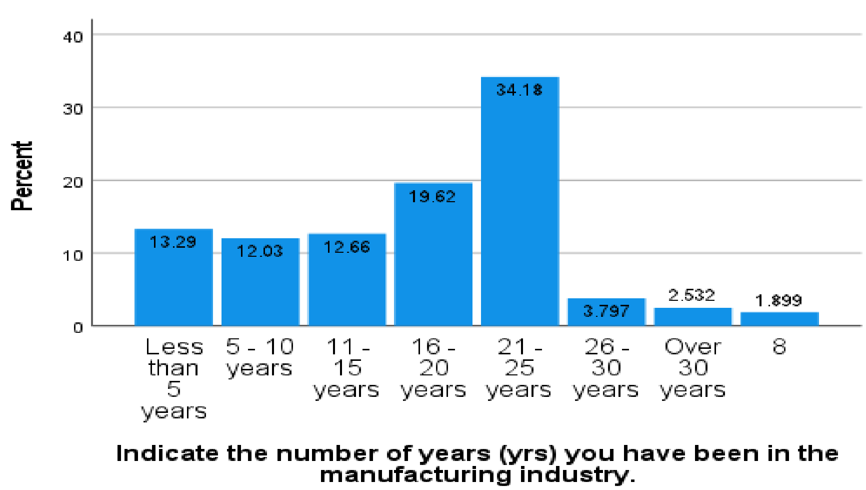

Figure 4.5: Respondents' years of work experience

4.8 Respondents' number of steel projects each employee

The respondents are shown in Figure 4.6 indicate the number of steel production each employee has been involved in the manufacturing industry. According to the results, 7.6% of respondents had 1 to 2 years, 14.6% of respondents had 3 to 4 years as well as 5 to 6 years, 26.6% of respondent had 7 to 8 years, 29.7% of respondents had 9 to 10 years, 3.8% of the respondents had more than 10 years, and 3.1% of respondents had not indicated.

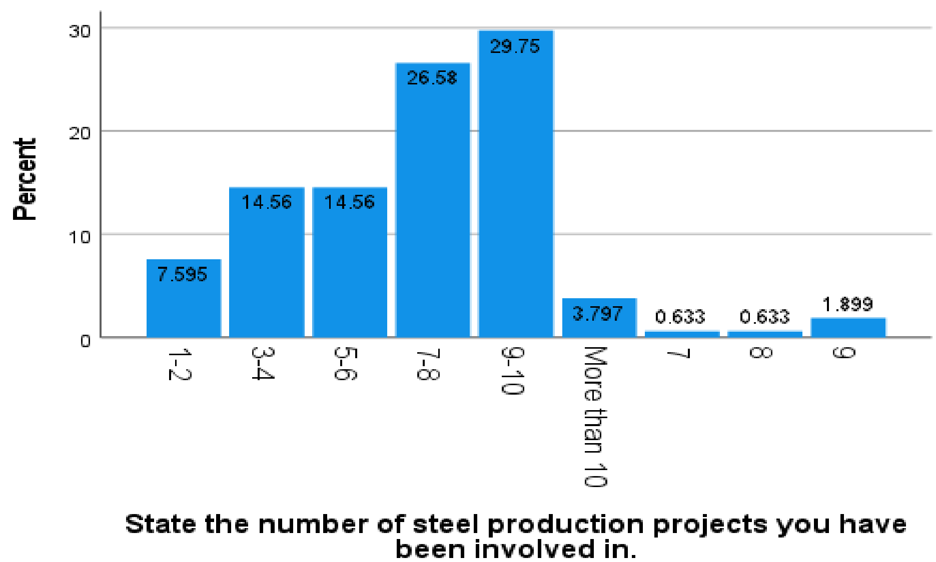

Figure 4.6: Employee involvement in steel production projects

4.9 Results of factors afftecting order fulfilment process

This section presents the results related to order processing delays and potential LSS advantages in South African manufacturing firms. The findings of the outcome of descriptive statistics and paired samples T- test, the Mean Item Score (MIS) plus skewness of items that are reported. In the table includes paired samples T- test values of mean and standard deviation. Descriptive result reveals that the ranking of T- test values from highest to lowest. One of three types for T-test analysis is a Paired sample t-test.

4.10 Outcome of descriptive analysis

Table 4.1 below presents the order processing possible delays solutions perceptions of its systems in the SA's manufacturing sector. Due to the fact that the frequencies could not be analysed, it was adopted and only descriptive testing was considered.

The respondents were questioned about how they believe LSS affects order processing from the viewpoint of the manufacturing business, using a five-point Likert scale of "Strongly disagree" (SD) to "Strongly agree" (SA). The respondents' assessments of order processing delays in the manufacturing sector, notably in Gauteng, are shown in Table 4.1.

Table 4.1: Perceived roles of Outsourced Product Development system

Perceived roles of OPD Systems: Manufacturing solution	**$\bar{x}$***	**σX****	**R****
The current order processing system is customer orientated	3.79	1.123	1
The improved manufacturing processes handle customers' problem and provide services right at the first time	3.76	1.121	2
Planning staff is trained	3.69	0.977	3
Current order process system benefits the customer.	3.64	1.039	4
The improved operational processes instils customer confidence	3.52	1.188	5
The production space is effectively designed	3.52	0.942	6
The current order process is effective	3.49	0.958	7
The improved operational processes provide prompt service to customer	3.46	1.070	8
Production process is designed for unexpected demand or peak season	3.43	1.162	9
Manufacturing staff is engaged	3.25	1.245	10

$\bar{x}$*: Mean item score; σX**: Standard deviation; R***: Rank

All statements below can be used to assess the possible delays of processing orders:

The findings of the study show that the current order processing system is customer orientated and ranks first, with a mean score of 3.79 and a standard deviation (SD) of 1.123; the improved manufacturing processes handle customers' problems and provide services right at the first time, ranks second with a mean score of 3.76 and a SD of 1.121; planning staff is trained as third ranked , with a mean score of 3.69 and SDs of 0.977; current order process system benefits the customer ranks fourth, had a mean score of 3.64 and a SD of 1.039; the production space is effectively designed and improved operational processes instil customer confidence were both ranked fifth, had a mean 3.52 and SDs of 0.942 and 1.188, respectively. From a production standpoint, these were the top five views of potential delays in order processing systems. Additionally, the sixth-ranked item which is the current order process is effective, had scored 3.49 mean and SD of 0.958; the seventh item rank, the improved operational processes provide prompt service to customer, had 3.46 mean and 1.070 standard deviation; the production process is designed for unexepected demand or peak ranks eighth, had 3.43 mean score and 1.162 standard deviation; and the manufacturing staff is engaged ranks as the ninth item, had 3.25 mean score and 1.245 standard deviation.

4.11 Paired samples statistics

Table 4.2 below shows the critical factors for successful implementation of LSSPI. This includes Mean (M), Number of respondents (N), Standard Deviation (SD), and Standard Error Mean (SEM).

Table 4.2: Paired samples T- test of LSSPI

Paired samples statistics					
		M*	N*	SD*	SEM*
Pair 1	C52 Frequency and quality of communication between workstations.	3.33	138	1.042	.089
	C26 Frequency and quality of communication between workstations.	3.67	138	1.033	.088
Pair 2	C51 Accessibility of manufacturing tools.	3.65	155	1.029	.083
	C25 Accessibility of manufacturing tools.	3.65	155	1.043	.084
Pair 3	C50 Use of the latest manufacturing plant by employees.	3.75	155	.983	.079
	C24 Use of the latest manufacturing plant by employees.	3.83	155	.986	.079

Paired samples statistics					
		M*	N*	SD*	SEM*
Pair 4	C49 Ability of the company to adapt to current technology.	3.63	155	1.087	.087
	C23 Ability of the company to adapt to current technology.	3.82	155	1.066	.086
Pair 5	C48 Relationship between targets and incentive rewards.	3.86	157	.937	.075
	C22 Relationship between targets and incentive rewards.	3.69	157	1.067	.085
Pair 6	C47 Competitiveness of employees' salaries (relative to competitors).	3.19	153	1.099	.089
	C21 Competitiveness of employees' salaries (relative to competitors).	3.75	153	1.059	.086
Pair 7	C46 The degree to which the organisation ensures a secure and healthy workplace.	3.33	150	1.208	.099
	C20 The level to which the organisation offers a secure and wholesome work atmosphere.	3.28	150	1.088	.089
Pair 8	C45 Extent to which the plant layout promotes efficiency.	3.23	155	1.193	.096
	C19 Extent to which the plant layout promotes efficiency.	3.38	155	1.058	.085
Pair 9	C44 The degree to which the layout design facilitates manufacturing processes.	3.61	155	1.066	.086
	C18 The level to which the arrangement of the floor plan facilitates the manufacturing process.	3.58	155	1.156	.093
Pair 10	C43 Frequency of quality housekeeping.	3.58	154	1.153	.093
	C17 Frequency of quality housekeeping.	3.69	154	1.005	.081
Pair 11	C42 Use of material handling equipment.	3.18	154	1.243	.100
	C16 Use of material handling equipment.	3.91	154	.979	.079
Pair 12	C41 Extent to which customer complaints are kept to a minimum level.	3.32	155	1.109	.089
	C15 Extent to which customer complaints are kept to a minimum level.	3.74	155	1.063	.085
Pair 13	C40 Extent to which customer return are kept to a minimum level.	3.34	157	1.107	.088
	C14 Extent to which customer return are kept to a minimum level.	3.55	157	1.179	.094
Pair 14	C39 Availability of manufacturing tools.	3.35	153	1.084	.088
	C13 Availability of manufacturing tools.	3.57	153	1.018	.082
Pair 15	C38 Availability of machine parts when needed for breakdown repairs.	3.21	155	1.155	.093
	C12 Availability of machine parts when needed for breakdown repairs.	3.77	155	1.126	.090
Pair 16	C37 Ability to the business to adhere to scheduled maintenance of machinery.	3.40	154	1.045	.084

Paired samples statistics					
		M*	N*	SD*	SEM*
	C11 Ability to the business to adhere to scheduled maintenance of machinery.	3.94	154	.919	.074
Pair 17	C36 Extent to which plant machinery is used to full capacity.	3.71	154	1.003	.081
	C10 Extent to which plant machinery is used to full capacity.	3.42	154	1.131	.091
Pair 18	C35 Ability of the business to remove bottlenecks.	3.59	154	1.076	.087
	C9 Ability of the business to remove bottlenecks.	3.43	154	1.131	.091
Pair 19	C34 Access to finance.	3.63	155	1.027	.082
	C8 Access to finance.	3.37	155	1.123	.090
Pair 20	C33 Ability of the business to reduce costs.	3.47	156	1.133	.091
	C7 Ability of the business to reduce costs.	3.96	156	.936	.075
Pair 21	C32 Experience level of employees.	3.72	152	1.117	.091
	C6 Experience level of employees.	3.62	152	1.168	.095
Pair 22	C31 Level of education of employees.	3.34	155	.742	.060
	C5 Level of education of employees.	3.80	155	1.015	.082
Pair 23	C30 Motivation level of employees.	3.15	119	.945	.087
	C4 Motivation level of employees.	3.03	119	1.248	.114
Pair 24	C29 Investing in training.	3.58	153	2.567	.208
	C3 Investing in training.	3.25	153	1.189	.096
Pair 25	C28 Investing in knowledge transfer.	3.22	154	.659	.053
	C2 Investing in knowledge transfer.	3.53	154	1.030	.083
Pair 26	C27 Investing in skills development.	3.39	151	.683	.056
	C1 Investing in skills development.	3.58	151	1.277	.104

M: Mean; *N: Number of respendants;*

SD.: Standard Deviation; *SEM: Standard Error Mean*

Based on the results, the value of Mean is ranged between 3.15 and 3.96. This indicates that the value between “Not Sure (3)” and closer to “Agree (4)”. In general, many responses had lower value of deviation between 3 and 4. This includes Pair 2-5, 7-16, and 18-26. This means that the reponses from participants are more opinions regarding the indicator. For instance, in Pair 2, C51 and C25, the mean values were between 3.63 and 3.86. This indicated that these respondents tend to agree with the accessibility of manufacturing tools within the organiation. According to Yan *et al.* (2021), the accessibility of manufacturing tools within the organiation are always important to employees.According Table 4.2, in Pair 1, C52 is closer to “Not Sure”, where C26 closer to “Agree” regarding the frequency and quality of communication between workstations. This is supported by Aad *et al.* (2020) as indicate in Pair 6.

4.12 Paired sample t-test

A paired T-test is used when each subject has a comparison measurements, to differentiate the score before and after (Frost, 2020).

To determine the change in the mean, use the paired-sample t-test to understand the significant difference from thezero value. Because it uses samples to make interpretations about populations, this test is an example of an inferential statistical procedure. It is often performed in the early stages of research to gather information about the interactions between many parameters (Pallant, 2007). Using IBM SPSS paired sample T- test was accepted. The tests necessary to determine whether the sample measurements are sufficient to proceed with a T-test study of the matched samples have been completed**.**

According to Frost (2020), to evaluate whether the hypothesis is testable, the population parametric test must have some correlations of t - value = 0. To determine the applicability and trustworthiness of the logic hypothesis testing,is that its significance differences amid both sample means or proportions (Burns *et al.,* 2008). A five-point Likert scale with the options "Strongly disagree" (SD) and "Strongly agree" was used to evaluate this section (SA). The ranking of elements that the respondents believe are essential for the effective use of the LSS indicator in the SA's manufacturing sector is shown in Table 4.3. The results show the presentation and discussion of the skewness of the data using the MIS results in question and the paired-samples t-test method. The relationship between company performance and the is influential of LSSPI on increase productivity was tested through paired sample t-test. These two categories were embedded in the survey questionnaire (see Appendix 2, Section C: Lean Six Sigma Perfomance Indicator (LSSPI) as the following:

A. To what extent is the company meeting the target for this metric?

B. How much of an impact has the increase in LSSPI had on your company's productivity?

Table 4.3: Paired Samples T-Test

		Paired Differences					t-value	df	Significance	
					95% Confidence Interval of the Difference					
		Mean	Std. Deviation	Std. Error Mean	Lower	Upper			One-Sided p-value	Two-Sided p-value
Pair 1	C52 - C26	-.341	1.380	.117	-.573	-.108	-2.899	137	.002	.004
Pair 2	C51 - C25	.006	1.556	.125	-.240	.253	.052	154	.479	.959
Pair 3	C50 - C24	-.077	1.488	.120	-.314	.159	-.648	154	.259	.518
Pair 4	C49 - C23	-.187	1.472	.118	-.421	.046	-1.583	154	.058	.116
Pair 5	C48 - C22	.172	1.437	.115	-.055	.399	1.499	156	.068	.136
Pair 6	C47 - C21	-.562	1.512	.122	-.804	-.321	-4.597	152	<.001	<.001
Pair 7	C46 - C20	.053	1.658	.135	-.214	.321	.394	149	.347	.694
Pair 8	C45 - C19	-.155	1.534	.123	-.398	.089	-1.257	154	.105	.211
Pair 9	C44 - C18	.026	1.615	.130	-.231	.282	.199	154	.421	.843
Pair 10	C43 - C17	-.110	1.659	.134	-.375	.154	-.826	153	.205	.410
Pair 11	C42 - C16	-.734	1.455	.117	-.965	-.502	-6.257	153	<.001	<.001
Pair 12	C41 - C15	-.419	1.498	.120	-.657	-.182	-3.484	154	<.001	<.001
Pair 13	C40 - C14	-.210	1.561	.125	-.456	.036	-1.687	156	.047	.094
Pair 14	C39 - C13	-.222	1.461	.118	-.456	.011	-1.881	152	.031	.062
Pair 15	C38 - C12	-.568	1.628	.131	-.826	-.309	-4.342	154	<.001	<.001
Pair 16	C37 - C11	-.532	1.339	.108	-.746	-.319	-4.935	153	<.001	<.001
Pair 17	C36 - C10	.286	1.579	.127	.034	.537	2.246	153	.013	.026
Pair 18	C35 - C9	.162	1.635	.132	-.098	.423	1.232	153	.110	.220
Pair 19	C34 - C8	.252	1.488	.120	.015	.488	2.105	154	.018	.037
Pair 20	C33 - C7	-.494	1.513	.121	-.733	-.254	-4.074	155	<.001	<.001
Pair 21	C32 - C6	.105	1.628	.132	-.156	.366	.797	151	.213	.427
Pair 22	C31 - C5	-.458	1.207	.097	-.650	-.266	-4.724	154	<.001	<.001
Pair 23	C30 - C4	.118	1.678	.154	-.187	.422	.765	118	.223	.446
Pair 24	C29 - C3	.320	2.774	.224	-.123	.763	1.428	152	.078	.155
Pair 25	C28 - C2	-.312	1.281	.103	-.516	-.108	-3.020	153	.001	.003
Pair 26	C27 - C1	-.192	1.441	.117	-.424	.040	-1.638	150	.052	.104

According to Table 4.3, the results showed that the paired samples T- test are as follows for the crucial implementation success elements of LSSPI are paired according to the evaluation of the probability of an occurrence: C1 to C26 represent statements as column A, and C27 to C52 represent statements as column B. This has been discussed as below.

- The first pair, C52 and C26 frequency and quality of communication between workstations had a mean score of 3.33, the respondents were closer to not sure, and had a mean score of 3.67, the respondents agree respectively.
- The second paired samples, both C51 and C25, accessibility of manufacturing tools had a mean score of 3.65 the respondents agree.
- The third paired samples, C50 and C24. Use of the latest manufacturing plant by employees had a mean score of 3.75 the respondents were closer to agree, and had mean score of 3.83 the respondents were closer to strongly agree respectively.
- Fourth paired samples test, C49 and C23 ability of the company to adapt to current technology had a mean score of 3.63 the respondents were closely to agree, and had mean score of 3.82 the respondents were closely to strongly agree respectively.
- Fifth paired samples,C48 and C22 relationship between targets and incentive rewards had a mean score of 3.86 the respondents were closely to strongly agree, and had mean score off 3.69 the respondents were closely to agree respectively.
- The phrase in C47 and C21 as the sixth paired samples competitiveness of employees' salaries (relative to competitors) had the mean score of 3.19 the respondents were closer to not sure and had a mean score of 3.75 the respondents were closer to agree respectively.
- Seventh paired samples test, C46 and C20 "The level to which the organisation offers a secure and wholesome work atmosphere" had a mean score of 3.33 the respondents were closer to not sure and had a mean score of 3.28 the respondents were closer to not sure respectively.

- Eighth paired samples test, C45 and C19 extent to which the plant layout promotes efficiency had a mean score of 3.23 and had a mean score of 3.38 the respondents were both closely to not sure respectively.
- The phrase, “the degree to which the layout design facilitates manufacturing processes” at paired samples number nine C44 and C18 had a mean score of 3.61 and had mean of 3.58 respectively the respondents were both closely to agree.
- Paired samples number ten C43 and C17 had a mean score of 3.58 and had amean score of 3.69 respectively the respondents were both closely to agree.
- Use of material handling equipment, which came in paired samples number eleven C42 and C16 had a mean score of 3.18 the respondents were closely to not sure and had 3.91 the respondents were closely to strongly agree respectively.
- Paired samples number twelve, C41 and C15, extent to which customer complaints are kept to a minimum level had a mean score of 3.32 the respondents were closely to not sure and had mean score of 3.74 the respondents were closely to agree respectively.
- C40 and C14 paired samples number thirteen had a mean score of 3.55 the respondents were closely to agree and had a mean score of 3.35 the respondents were closely to not sure respectively.
- Paired samples number fourteen C39 and C13 availability of manufacturing tools had a mean score of 3.35 the respondents were closely to not sure and had a mean score of 3.57 the respondents were closely to agree.
- Paired samples number fifteen C38 and C12 had a mean score of 3.21 the respondents were closely to not sure and had a mean score of 3.77 the respondents were closely to strongly agree.
- Ability to the business to adhere to scheduled maintenance of machinery as paired samples number sixteen, C37 and C11 had a mean score of 3.40 the respondents were closely to not sure and had a mean score of 3.94 the respondents were closely to strongly agree respectively.

- Paired samples number seventeen, C36 and C10, extent to which plant machinery is used to full capacity, had a mean score of 3.71 the respondents were closely to agree and had a mean score of 3.42 the respondents were closely to not sure respectively.
- The phrase in paired samples number eighteen C35 and C9 ability of the business to remove bottlenecks, had a mean score of 3.59 the repsondents were closely to agree and had a mean score of 3.43 te respondents were closely to not sure respectively.
- Access to finance as paired samples number nineteen, C34 and C8 had a mean score of 3.63 the respondents were closely to agree and had a mean score of 3.37 the respondents were closely to not sure respectively.
- Paired samples number twenty C33 and C7 ability of the business to reduce costs, had a mean score of 3.47 the respondents were closely to not sure and had a mean of 3.96 the respondents were closely to strongly agree.
- Paired samples number twenty one C32 and C6 experience level of employees, had a mean score of 3.72 and had a mean score of 3.62 both respondents were closely to agree respectively
- The paired samples number twenty two C31 and C5, had a mean of 3.34 the respondents were closely to not sure and had a mean of 3.80 the respondents were closely to strongly agree respectively.
- Number twenty three of paired samples C30 and C4 motivation level of employees , had a mean of 3.15 and had a mean of 3.03 both the respodents were closely to not sure respectively.
- C29 and C3 were paired samples number twenty four with a phrase about investing in training, had a mean of 3.58 the respondents were closely to agree and had a mean of 3.25 the respondents were closely to not sure respectively.
- Paired samples number twenty five C28 and C2, investing in knowledge transfer had a mean of 3.22 the respondents were closely to not sure and had a mean of 3.53 the respondents were closely to agree respectively.
- The phrase investing in skills development in paired samples

number twenty six had a men of 3.39 the respondents were closely to not sure and had a mean of 3.58 the respondents were closely to agree respectively.

4.13 Conclusion

This chapter examined essential information that the researcher collected using a well-constructed survey. The respondents were manufacturing professionals in South Africa's Gauteng Province, including consultants, operations managers, production experts, production managers, procurement officials, and financial analysts. Data were presented in tables and graphs. The discourse of the discoveries and conclusions of the investigation consider in connection to the inquiry about questions and objectives is the most reason for the consequent chapter.

CHAPTER 5: CONCLUSION AND RECOMMENDATIONS

5.1 Introduction

The purpose of this research aims to identify the dominant influences of Lean Six Sigma (LSS) on order fulfilment processes in the South African manufacturing sector. Furthermore, it explored the factors affecting order fulfilment, advantages of LSS, the difficulties of implementing LSS, and finally, potential recommendations for improving order fulfilment processes in the manufacturing sector within South Africa. Orders must be formed because of the demand for products to be consumed by end users before goods are manufactured by manufacturing companies and made available in the market. This is the driving force behind an effective and efficient order processing system. This is crucial in the complicated, demanding, and competitive world of today to meet the wants or expectations of clients. This chapter discusses the research study's results and suggestions in connection to its goals. The chapter further provides conclusions and responds to the research questions. Recommendations are made in terms of further research and practice.

5.2 Conclusion regarding research objectives

5.2.1 Research objective 1

Identify critical order fulfilment parameters in South African manufacturing businesses.

Thus, there is a significant opportunity to improve in South African manufacturing industries on order fulfilment processes. The efficiency of ordering fulfilment processes in manufacturing organisation helps to plan for an effective production system. An accurate schedule of inventory is critical to manage the fulfilment of customer’ orders. To manage order fulfilment and invertory schedules it is critical that manufacturing sectors are frequently planning for production and service its customers continuously.

The complex market, fierce competition and constantly changing needs require businesses to be flexible . The ability to quickly adapt to the changes of the market is referred to as flexibility. Customers no longer demand quality; rather, the customers anticipate it. If this expectation is not reached, it may cause further delays because, for example, the product may need to be redone. It is critical not to compromise the service or product quality of an industry as this could lead to order processing delays.

To use a five-point Likert scale of "Strongly disagree" to "Strongly agree," a questionnaire survey completed by randomly chosen respondents indicated that the following elements were regarded as the key characteristics likely to affect the order fulfilment process. The study's findings show that the use of the latest manufacturing plant by employees which is found in pair three, was the highest with the mean score of 3.83 and SDs of 0.986, ability fo the company to adapt to current technology found in pair four was second highest with 3.82 mean score and SDs of 1.066. extend to which the floor plandesign support manufacturing in pair nine is also thirdly ranked with 3.58 mean score and SDs 1.156 and at last,in pair 8,the extent to which the plant layout promotes efficiency was fourth in order with a mean score of 3.23 and SDs of 1.193. From a manufacturing standpoint, these were the top four most typical views of potential issues that might impact order fulfilment process systems.

5.2.2 Research objective 2

Examine Lean Six-manufacturing sigma's advantages

According to the literature, one of the major advantages to implement six-sigma in lean manufacturing is the shortening of project lifecycle times. One can establish a team comprising a group of seasoned experts from various departments and assign roles using the six-sigma methodology. This team would pinpoint significant project-delaying problems. The project manager will instruct them to find solutions after identifying the root cause. Enhancing company operations and quality assurance with LSS increases customer satisfaction. The adoption of Lean Six Sigma manufacturing in the South African context is notably improving the causes of delay in production subsequently, to the order process and production space that is effectively designed.

Low failure rates, low prices, and high quality are characteristics of well - finished goods. When there is a high-quality product, customers are thrilled. An improvement of employee continuous training on Lean manufacturing to present relevance and competence to the industry is critical. By so doing the increased in product quality will result in a profitable organisation.

Employees would be motivated to work hard and provide the expected outcomes. Additionally, staff members are content with six sigma, as are with consumers. The actions and responses of an organisation's employees determine its success. Additionally, it supports lean and strategic company planning. Six sigma seeks to reduce product flaws while ensuring product functionality and service quality to sell high-quality services.

The organisation will succeed to effective implementation of six sigma. The following factors were the key advantages of applying LSS to order fulfilment process. The current order processing system is customer orientated and ranks first, with a mean score of 3.79 and a standard deviation (SD) of 1.123; the improved manufacturing processes handle customers' problems and provide services right at the first time, ranks second with a mean score of 3.76 and a SD of 1.121; planning staff is trained as third ranked , with a mean score of 3.69 and SDs of 0.977; current order process system benefits the customer ranks fourth, had a mean score of 3.64 and a SD of 1.039; the production space is effectively designed and improved operational processes instil customer confidence were both ranked fifth, had a mean 3.52 and SDs of 0.942 and 1.188, respectively. From a production standpoint, these were the top five views of potential delays in order processing systems. Additionally, the sixth-ranked item which is the current order process is effective, had 3.49 mean score and 0.958 SD; the seventh-ranked item, the improved operational processes provide prompt service to customer, had 3.46 mean and 1.070 standard deviation; the production process is designed for unexepected demand or peak ranks eighth, had 3.43 mean score and 1.162 standard deviation; and the manufacturing staff is engaged ranks as the ninth item, had 3.25 mean and SD of 1.245.

5.2.3 Research objective 3

Determine Lean Six- sigma problems in manufacturing.

Since workers are regarded as the heart and soul of every business, their lack of participation is one of the most significant obstacles to the implementation of LSS, according to the literature. This result in lack of customer service in improving operational processes in the manufacturing industry and manufacturing processes that handle customers' problems in providing service right at the first time. The Lack of employee engagement in the production process can affect the manufacturing industry negatively in order processing process. Employees must be active in the process and drive Continuous Improvement, which is a fundamental element of lean if a business is to successfully embrace it. The organisational culture is the second major obstacle; it is the subject of one of the most frequent lean complaints.

The issue has been extensively discussed in the literature for many years, and everyone working at the company has the same ideals, presumptions, and opinions. Performance is impacted by individual behaviour, which is impacted by organisational culture. Lack of shareholder commitment is another major issue. This may have an impact on the adoption of lean; support from the organisation's key stakeholders is essential.

Stakeholder involvement is essential to many firms in all aspects of the business. Most firms are unable to incur significant expenditures without the approval of their stakeholders, particularly when the funds aren't directly tied to consumers. Lean and the restructuring process may be seen as too risky to undertake if they are not clearly explained to stakeholders. Effective or poor company-wide communication may also have an impact on the adoption of lean. Even though many businesses claim to have strong departmental communication, misunderstandings may undermine attempts to embrace lean.

5.2.4 Research objective 4

To contribute possible recommendations that can be used to improve the order fulfilment process of manufacturing companies

According to the literature, DMAIC is a potential method that might be used to enhance the order fulfilment process. In the realm of business, DMAIC is a business strategy utilised to increase company profitability, to improve the efficacy and efficiency of all processes to meet or exceed customer wants and expectations As a closed-loop process, it often focuses on fresh measurements, removes unnecessary procedures, and leverages technology to continuously improve. By putting this plan into action, management will enhance order processing systems immediately. Six sigma is a data-driven, systematic methodology. Improving an organisation's sigma capacity by the rigorous use of statistical tools and methodologies is the core tenet of DMAIC.

The findings revealed that the order fulfilment process would be more effective if the LSS performance indicator can be included as part of DMAIC principles. According to the results, the five Most Important Success Factors for LSSPI Implementation are found in pair 20 whereby;the ability of the business to reduce costs has the highest of 3.96 mean score and 0.936 of SD; ability to the business to adhere to scheduled maintanance was found in pair 16 and came in second place with 3.94 mean score and a 0.919 SD; use of material handling ecquipment was found in pair 11 and came in third place with a mean of 9.91 and a SD of 0.979, and level of employees education was found in pair 22 and is ranked fourth with the mean score 3.80 and 1.015 SD. Lastly, availability of machine parts when neeed for breakdown repairs was found in the first pairl which ranks fifth with 3.77 mean score and 1.126 SD.

5.3 Implication of the study

5.3.1. Implications of the study to acquire LSS in the manufacturing sector

The implication of this study firstly was that the manufacturing sector need to enhance the lean six sigma implementation to improve the number of employees with the necessary skill being equipped inclusively. This implication is based on the demand that the manufacturing sector needs.

The second implication of this study that was identified as the order fulfilment process gap in South African manfucturing industry. To critically identify the opportunities to improve efficiency of order processes, the scheduling of inventory management system must meet the needs of customers.

5.3.2 Implications of the study to adopt lean six sigma in South African context

To improve a project lifecycle period a critical analysis to benefit in lean manufacturing increases customer satisfaction. The significant role to minimise delays in the sector is an accurate scheduling plan that will make provision for the unforeseen operations plans. The implication of the study in the manufacturing industry for South Africa is an implementation of continuous improvement program for lean six sigma to the company at large according to its employee ranking for an effective product quality.

5.3.3 Implication of the study to problem solving of lean six sigma

The implication of this study to improve on employee involvement to lean six sigma in all levels, and training be provided for staff development. To train employees frequently boost the industry reputation and result in manufacturing sector competitive globally. Improvement of production order processing has an impact in employee engagement for the manufacturing sector.

5.4 Recommendations

5.4.1 Adopt LSS for operations and order fulfilment processes

This suggestion aims to develop a LSS implementation plan to fulfil orders and prevent the issues highlighted in the literature. Based on the literature and questionnaire evaluations, it is advised that LSS be used to simplify and enhance order fulfilment processes. To make sure that the ordering process flow is sufficient, it is also advised that approaches like DMAIC be used. The implementation of DMAIC approach in the order fulfiment processes will positively contribute to the commitments of employees and engagement of management in the manufacturing industry.

5.4.2 Communication between employees and management

Additionally, it is advised that communication should be a key driving force in the company's strategy because it is crucial to ensure that the workers who will primarily be responsible for implementing LSS in the order fulfilment process are fully aware of the changes that are coming and will be less likely to resist them. If the organisation has many workers, it would be hard to make contact personally with each one at the same time through channels like meetings. The relationship of the manufacturing industry managers and its employees would be improved by the effectiveness and proficiency of good practices of lean six sigma.

5.4.3 Implementation of LSS in South African manufacturing sector

The recommendation to implement an effective LSS will benefit the South African manufacturing industry to fulfil the efficiency of its ordering process. The enhancement of lean and six sigma is assumed to produce an extensive industry opportunities globally. The study proves that the integration of LSS into the manufacturing sector will improve order processing and accuracy of data as well as data security. It is advised that organisations to adapt in LSS implementation to improve its customer satisfaction. LSS is used to optimise its approach that is aimed at waste reduction, improved production processes in any manufacturing organisation.The implementation results are not limited to an increase of quality and improved productivity, but to change aspects that are not physical.

5.4.4 Maintenance process of LSS in the order fulfilment process

It is advised that the order fulfilment process is a value added process that focuses on the customer requirement. To maintan these processes the manufacturing industries must optimise the proceses of supply chain and focus on meeting customer standards. To provide the accurate key performance indicators for the manufacturing industries it is advisable that accurate systems on order fulfilment must be a key factor to tasks specifications.

It is recommended that the organisation should contact the workers via email, for example, about LSS, to ask them when the industry want to implement it, how it will affect its existing workplace, and what industry opinions or recommendations are regarding LSS. It could be easier for employees who are reluctant to speak out in meetings to communicate through email. Employees could also be reached using letters or brochures. Moreover, it is recommended that all staff members, particularly those who are skeptical or resistant, are adequately briefed on the benefits of implementing LSS in the order fulfillment process, how it would directly impact the employees, and its role in both the implementation and maintenance processes.

5.5 Limitation and Recommendations for Future Research

5.5.1 Limitation to conduct the research to the entire province

The view point of this study does not represent the broad opinions of the whole industry in South Africa. The implication of this research was conducted to limited manufacturing industries in Gauteng rather than to the broader sector in the province. The basis of this implication has resulted to individuals that had relevant knowledge and skills in lean six sigma, other employees from the companies were excluded, however those that were included the possibility would be the contribution of opinions in the implementation stage. The two companies that were selected to conduct the research revealed that although there were more than three hundred employees in each manufacturing industry, the majority of employees lack the lean six sigma understanding.

It is recommended that employees must be granted the required training in order for the company to be effective and productive in its order fulfilment proces.This would lower the dependency on few employees that are qualified as LSS practitioners completely.

5.5.2 Limitation to conduct the research to South African manufacturing countries

The implication of conducting this research to South Africa has resulted inaccuracy of lean six sigma's effectiveness. The benchmarking with other countries would give a better perspective to the order fulfilment process in the manufacturing sector. The improvement strategy becomes effective when the study comparsion is accurate.

Development of lean six sigma in order fulfilment process in the manufacturing sector is critical and should be priority number one to all companies of this nature.This should be preceded by the implementation of LSS in standard operations procedures.

The research study has contributed on effective application of LSS to the body of knowledge to improve the order processing in the manufacturing industy using DMAIC approach. The manufacturing industry must implement a six sigma roles certification in order for the implementation be improved. The ranking will assist the industry to build on the skills each employee has so that the company can function and run its operations without any delays.

5.5.3 Limitation to conduct the research globally

The research study does not present a global perspective of lean six sigma in the manufacturing sector. The limitations affect the effectiveness of good practice globally. The development for the sustainable framework to improve critical success factors of LSS has been limited to few companies in the manufacturing sector. The limitations to implement lean six sigma programmes, to improve its competitiveness and capacity towards the globalisation market has been identified by this research study.

5.6 The recommendations for the future research

5.6.1 The measurement metric on equipment efficiency

The appropriate Overall Equipment Effectiveness guidelines and standard operating procedures have been developed. A systematic technique for equipment effectiveness is at its advanced stage as well as its effieciency.

5.6.2 Simulation of a learning factory in manufacturing

This study has proven that having to implement a learning factory that differs to the existing ones, with a significant hands –on model will benefit the manufacturing industries. The learning factory needs to identify components on Industry 4.0 that are identified as a gap to the manufacturing sector.

5.6.3 The effect of six sigma ranking certification in manufacturing

The consistent trainings, mentoring programms will be required in the manufacturing sector to increase its employees knowledge, in order to gain better opportunities. The integration reflection lessons from the successful six sigma and other approach. The best appropriate techniques for six sigma' effectiveness and good practices are to thoroughly refine its organisational structures as a continuous improvement plan for the businesses.

5.6.4 The involvement of LSS experts in manufacturing industry

The complexity of systems in manufacturing industry will increase the digital integrated Industry 4.0. Indeed, to increase its digital aspect of manufacturing organisation would have an impact in the global chain. Engineers with an evolving knowledge would be beneficial to the manufacturing industry.

5.7 Conclusion

The research was only conducted in the province of Gauteng in South Africa, and several participants with extensive experience in LSS in the manufacturing industry did not complete the questionnaire. More research may be conducted utilising a larger study area and much more respondents to have a better understanding of the research topic. In the Gauteng area, this research was carried out in the private sector. To conduct the best LSS research, it is necessary to consider that individuals with LSS expertise may have a different profile than workers in other sectors. A future investigation could reveal if the results are exclusive to the industrial sector or representative of the overall market.

The research recommendations emanating from the questionnaire results that are presented in chapter 4. A proposed collaboration with other manufacturing industries in the province at large, in South Africa and the global market will improve lean six sigma operations on order fulfilment processes. Lean and six sigma are identified as the significant measurements of order fulfilment process in the manufacturing sector to bring stabililty in its operations and approach. To ensure that the order fulfilment is accurately implemented,the principles and techniques of lean six sigma must be adopted for the favourable results.

REFERENCES

Aad, G., Abbott, B., Abbott, D.C., Ambroz, L., Artoni, G., Backes, M., Balunas, W.K., Barr, A.J., Beresford, L., Bortoletto, D. and Cooper-Sarkar, A.M., 2020. ATLAS data quality operations and performance for 2015–2018 data-taking. *Journal of instrumentation*, *15*(04).

Abdellatif, H. and Alshibani, A., 2019. Major factors causing delay in the delivery of manufacturing and building projects in Saudi Arabia. *Buildings*, *9*(4), p.93.

Aboelmaged, M.G., 2011. Reconstructing Six Sigma barriers in manufacturing and service organisations: The effects of organisational parameters. *International Journal of Quality & Reliability Management*, *28*(5), pp.519-541.

Archer, M., Marajh, D.N., Visser, M.S. and Fernandes-Whaley, M., 2017. Use of accumulated proficiency testing scheme results to evaluate laboratory performance in forensic ethanol analysis. *Journal of Chemical Metrology*, *11*(2).

Adeodu, A.O., Kanakana-Katumba, M.G. and Maladzhi, R., 2020, December. Implementation of Lean Six Sigma (LSS) Methodology, through DMAIC Approach to Resolve Down Time Process; A Case of a Paper Manufacturing Company. In *Proceedings of the 2nd African International Conference on Industrial Engineering and Operations Management* (pp. 37-47).

Adeodu, A., Kanakana-Katumba, M.G. and Rendani, M., 2021. Implementation of Lean Six Sigma for production process optimization in a paper production company. *Journal of Industrial Engineering and Management*, *14*(3), pp.661-680.

Ahmad, S.A.S., 2013. Culture and lean manufacturing: towards a holistic framework.

Ahmed, I., 2013. Reducing process variability by using DMAIC model: a case study in Bangladesh. *International Journal for Quality Research*, *7*(1), pp.127-140.

Ahmed, S., Abd Manaf, N.H. and Islam, R., 2018. Measuring Lean Six Sigma and quality performance for healthcare organisations. *International Journal of Quality and Service Sciences*, *10*(3), pp.267-278.

Ahmed, S., Manaf, N.H., Islam, R. 2013. Effects of Lean Six Sigma application in healthcare services: a literature review. Reviews on environmental health. 28(4):189-194.

Akmal, A., Foote, J., Podgorodnichenko, N., Greatbanks, R. and Gauld, R., 2022. Understanding resistance in lean implementation in healthcare environments: an institutional logics perspective. *Production Planning & Control*, *33*(4), pp.356-370.

Alblooshi, M., Shamsuzzaman, M., Khoo, M.B.C., Rahim, A. and Haridy, S., 2021. Requirements, challenges and impacts of Lean Six Sigma applications–a narrative synthesis of qualitative research. *International Journal of Lean Six Sigma*, *12*(2), pp.318-367.

Al-Dhaafri, H.S. and Alosani, M.S., 2020. Impact of total quality management, organisational excellence and entrepreneurial orientation on organisational performance: empirical evidence from the public sector in UAE. *Benchmarking: An International Journal*, *27*(9), pp.2497-2519.

Alfeno, S. and Rifai, D., 2019. Utilisation of the Django Framework as a Dashboard Model Information System for Raw Material Inventory on PT Bimasakti Karyaprima. *Aptisi Transactions On Technopreneurship (ATT)*, *1*(2), pp.192-202.

Almohaimmeed, B., 2019. Pillars of customer retention: An empirical study on the influence of customer satisfaction, customer loyalty, customer profitability on customer retention. *Serbian Journal of Management*, *14*(2), pp.421-435.

Al-Najem, M., 2014. *Investigating the factors affecting readiness for lean system adoption within Kuwaiti small and medium-sized manufacturing industries* (Doctoral dissertation, University of Portsmouth).

Al-Najem, M., Garza-Reyes, J.A. and ElMelegy, A., 2019. Measuring the lean readiness of Kuwaiti manufacturing industries. *International Journal of Business Performance Management*, *20*(1), pp.70-92.

Alomari, K., 2021. Identifying critical success factors in designing effective and efficient supply chain structures: A literature review. *Uncertain Supply Chain Management*, *9*(2), pp.447-456.

Alyousef, A., 2019. The Challenges And Barriers Facing Successful Lean Implementation In The Qatari Manufacturing Organisations.

Alzoubi, H.M., In'airat, M. and Ahmed, G., 2022. Investigating the impact of total quality management practices and Six Sigma processes to enhance the quality and reduce the cost of quality: the case of Dubai. *International Journal of Business Excellence*, *27*(1), pp.94-109.

Amankwa, E., 2018. *Factors Influencing Sustainable Operations Management Development in the Dairy Manufacturing Sector in Johannesburg*. University of Johannesburg (South Africa).

Anderson, V., 2017. Criteria for evaluating qualitative research. *Human Resource Development Quarterly*, pp.1-9.

Andersson, J.A., Gillis, J., Horn, G., Rawlings, J.B. and Diehl, M., 2019. CasADi: a software framework for nonlinear optimisation and optimal control. *Mathematical Programming Computation*, *11*, pp.1-36.

Andersson, R. and Pardillo-Baez, Y., 2020. The Six Sigma framework improves the awareness and management of supply-chain risk. *The TQM Journal*, *32*(5), pp.1021-1037.

Angelis, J. and Fernandes, B., 2012. Innovative lean: work practices and product and process improvements. *International Journal of Lean Six Sigma*, *3*(1), pp.74-84.

Antony, J., 2011. Six Sigma vs Lean: Some perspectives from leading academics and practitioners. *International Journal of Productivity and Performance Management*, *60*(2), pp.185-190.

Antony, J., 2012. A SWOT analysis on Six Sigma: some perspectives from leading academics and practitioners. *International Journal of Productivity and Performance Management*, *61*(6), pp.691-698.

Antony, J., Krishan, N., Cullen, D. and Kumar, M., 2012. Lean Six Sigma for higher education institutions (HEIs) Challenges, barriers, success factors, tools/techniques. *International Journal of Productivity and Performance Management*, *61*(8), pp.940-948.

Antony, J., Rodgers, B. and Gijo, E.V., 2016. Can Lean Six Sigma make UK public sector organisations more efficient and effective?. *International Journal of Productivity and Performance Management*, *65*(7), pp.995-1002.

Arlbjørn, Jan Stentoft, and Per Vagn Freytag. "Evidence of lean: A review of international peer-reviewed journal articles." *European Business*

Review 25, no. 2 (2013): 174-205.

Arndt, T., Kumar, M., Lanza, G., Tiwari, M.K. 2019. Integrated approach for Optimising quality control in international manufacturing networks. Production Planning & Control. 30(2-3):225-238.

Ashok Sarkar, S., Ranjan Mukhopadhyay, A. and Ghosh, S.K., 2013. Improvement of claim processing cycle time through Lean Six Sigma methodology. *International journal of lean six sigma*, *4*(2), pp.171-183.

Atieh, A.M., Kaylani, H., Al-Abdallat, Y., Qaderi, A., Ghoul, L., Jaradat, L. and Hdairis, I., 2016. Performance improvement of inventory management system processes by an automated warehouse management system. *Procedia Cirp*, *41*, pp.568-572.

Azarhoushang, B., Bramucci, A., Herr, H. and Ruoff, B., 2015. Value chains, underdevelopment and union strategy. *International Journal of Labour Research*, *7*(1/2), pp.153-175.

Babbie, E.R., Halley, F. and Zaino, J., 2007. *Adventures in social research: data analysis using SPSS 14.0 and 15.0 for Windows*. Pine Forge Press.

Bag, S., Wood, L.C., Xu, L., Dhamija, P. and Kayikci, Y., 2020. Big data analytics as an operational excellence approach to enhance sustainable supply chain performance. *Resources, Conservation and Recycling*, *153*, p.104559.

Barney, J. 2007. Firm resources and sustained competitive advantage. *Journal of management.* 17(1): 99-120.

Bazrkar, A., Iranzadeh, S. and Feghhi Farahmand, N., 2017. Total quality model for aligning organisation strategy, improving performance, and improving customer satisfaction by using an approach based on combination of balanced scorecard and lean six sigma. *Cogent Business & Management*, *4*(1), p.1390818.

Berg, B.L., 2001. *Qualitative research methods for the social sciences*. Allyn & Bacon.

Berry, D.R., Cortes-Guzman, K.P., Durand-Silva, A., Perera, S.D., Remy, A.K., Yan, Q. and Smaldone, R.A., 2021. Supramolecular tools for polymer additive manufacturing. *MRS Communications*, *11*, pp.146-156.

Bhamu, J. and Singh Sangwan, K., 2014. Lean manufacturing: literature review and research issues. *International Journal of Operations & Production Management*, *34*(7), pp.876-940.

Bhasin, S., 2012. Prominent obstacles to lean. *International Journal of Productivity and Performance Management*, *61*(4), pp.403-425.

Bhasin, S., Kamalapurkar, R., Johnson, M., Vamvoudakis, K.G., Lewis, F.L. and Dixon, W.E., 2013. A novel actor–critic–identifier architecture for approximate optimal control of uncertain nonlinear systems. *Automatica*, *49*(1), pp.82-92.

Bhat, S., Gijo, E.V. and Jnanesh, N.A., 2014. Application of Lean Six Sigma methodology in the registration process of a hospital. *International Journal of Productivity and Performance Management*, *63*(5), pp.613-643.

Bhuiyan, N. and Baghel, A., 2015. An overview of continuous improvement: from the past to the present. *Management decision*, *43*(5), pp.761-771.

Bicheno, J. and Holweg, M., 2016. *The lean toolbox* (Vol. 4). Buckingham: PICSIE books.

Bishop, Michael L. *Clinical Chemistry: Principles, Techniques, and Correlations, Enhanced Edition: Principles, Techniques, and Correlations*. Jones & Bartlett Learning, 2020.

Black, J.T. and Kohser, R.A., 2020. *DeGarmo's materials and processes in manufacturing*. John Wiley & Sons.

Boldt, E. and Franchetti, M., 2013. Total Sustainability Assessments for Manufacturing Operations Using the Lean Six Sigma Approach. *Science Journal of Environmental Engineering Research*, *2013*.

Bonzo, S.M., Liker, J.K., Grams, K.E. and Dickason, K.S., 2018. Organic versus mechanistic approaches to system-wide improvement: Reducing delays to critical care. *IISE Transactions on Healthcare Systems Engineering*, *8*(4), pp.280-290.

Borenstein, M., Hedges, L.V., Higgins, J.P. and Rothstein, H.R., 2021. *Introduction to meta-analysis*. John Wiley & Sons.

Brandão, C., 2015. P. Bazeley and K. Jackson, qualitative data analysis with Nvivo (2013). London: Sage.

Brown, A. and Green, T., 2016. Virtual reality: Low-cost tools and resources for the classroom. *TechTrends*, *60*, pp.517-519.

Bryman, A., 2017. Quantitative and qualitative research: further reflections on their integration. In *Mixing methods: Qualitative and quantitative research* (pp. 57-78). Routledge.

Buer, S.V., Strandhagen, J.O. and Chan, F.T., 2018. The link between Industry 4.0 and lean manufacturing: mapping current research and establishing a research agenda. *International journal of production research*, *56*(8), pp.2924-2940.

Burns, E. and Groove, W., 2014. Research method. *Ergonomics*, *32*(3), pp.237-248.

Burns, M., 2019. Containerised cargo security at the US–Mexico border: how supply chain vulnerabilities impact processing times at land ports of entry. *Journal of Transportation Security*, *12*, pp.57-71.

Burns, R. and Burns, R.P., 2008. Business Research Methods and Statistics Using SPSS: What, Why and How?. *Business Research Methods and Statistics Using SPSS*, pp.1-560.

Chang, J.F., 2016. *Business process management systems: strategy and implementation*. CRC Press.

Chen, K.S., Chen, H.T. and Chang, T.C., 2017. The construction and application of Six Sigma quality indices. *International Journal of Production Research*, *55*(8), pp.2365-2384.

Chen, R., Lee, Y.D. and Wang, C.H., 2020. Total quality management and sustainable competitive advantage: serial mediation of transformational leadership and executive ability. *Total Quality Management & Business Excellence*, *31*(5-6), pp.451-468.

Chiarini, A., 2012. Risk management and cost reduction of cancer drugs using Lean Six Sigma tools. *Leadership in Health Services*, *25*(4), pp.318-330.

Chow-Chua, C., Goh, M. and Boon Wan, T., 2003. Does ISO 9000 certification improve business performance?. *International journal of quality & Reliability management*, *20*(8), pp.936-953.

Chugani, N., Kumar, V., Garza-Reyes, J.A., Rocha-Lona, L. and Upadhyay, A., 2017. Investigating the green impact of Lean, Six Sigma and Lean

Six Sigma: A systematic literature review. *International Journal of Lean Six Sigma*, *8*(1), pp.7-32.

Clancy, R., Bruton, K., O'Sullivan, D.T. and Cloonan, A.J., 2022. The HyDAPI framework: a versatile tool integrating Lean Six Sigma and digitalisation for improved quality management in Industry 4.0. *International Journal of Lean Six Sigma*.

Colbourn, T., Pulkki-Brännström, A.M., Nambiar, B., Kim, S., Bondo, A., Banda, L., Makwenda, C., Batura, N., Haghparast-Bidgoli, H., Hunter, R. and Costello, A., 2015. Cost-effectiveness and affordability of community mobilisation through women's groups and quality improvement in health facilities (MaiKhanda trial) in Malawi. *Cost Effectiveness and Resource Allocation*, *13*(1), pp.1-15.

Cordero, P.M., Mireles, J., Ridwan, S. and Wicker, R.B., 2017. Evaluation of monitoring methods for electron beam melting powder bed fusion additive manufacturing technology. *Progress in Additive Manufacturing*, *2*, pp.1-10.

Costa, T., Silva, F.J.G. and Ferreira, L.P., 2017. Improve the extrusion process in tire production using Six Sigma methodology. *Procedia manufacturing*, *13*, pp.1104-1111.

Coyle, J.J., Gibson, B.J., Langley, C.J. and Novack, R.A., 2013. *Managing supply chains: A logistics approach*. South-Western Cengage Learning.

Cropley, A.J., 2019. Qualitative research methods: A practice-oriented introduction for students of psychology and education. *Riga, Latvia: Zinātne.(open access–doi: 10.13140/RG. 2.1. 3095.6888)*.

Culler, E.W., 2009. The degree of relationship between critical success factors and information technology project performance. *Doctoral dissertation, University of Phoenix.*

Cusumano, M.A., Holweg, M., Howell, J., Netland, T., Shah, R., Shook, J., Ward, P. and Womack, J., 2021. Commentaries on "The lenses of lean". *Journal of Operations Management*, *67*(5), pp.627-639.

Dahl, J., 2019. *Leading lean: ensuring success and developing a framework for leadership*. " O'Reilly Media, Inc.".

Daniyan, I., Adeodu, A., Mpofu, K., Maladzhi, R. and Katumba, M.G.K.K., 2022. Application of lean Six Sigma methodology using DMAIC approach for the improvement of bogie assembly process in the railcar industry. *Heliyon*, *8*(3).

Dauda, Y.A. and Akingbade, W.A., 2011. Technological change and employee performance in selected manufacturing industry in Lagos state of Nigeria. *Australian journal of business and management research*, *1*(5), pp.32-43.

Davis-Sramek, B., Ishfaq, R., Gibson, B.J. and Defee, C., 2020. Examining retail business model transformation: a longitudinal study of the transition to omnichannel order fulfillment. *International Journal of Physical Distribution & Logistics Management*, *50*(5), pp.557-576.

Davies, J., Maru, Y., Hall, A., Abdourhamane, I.K., Adegbidi, A., Carberry, P., Dorai, K., Ennin, S.A., Etwire, P.M., McMillan, L. and Njoya, A., 2018. Understanding innovation platform effectiveness through experiences from west and central Africa. *Agricultural Systems*, *165*, pp.321-334.

Deflorin, P. and Scherrer-Rathje, M., 2013. Trade-offs are not exogenous. *International Journal of Production Research*, *51*(15), pp.4644-4666.

Deshkar, A., Kamle, S., Giri, J. and Korde, V., 2018. Design and evaluation of a Lean Manufacturing framework using Value Stream Mapping (VSM) for a plastic bag manufacturing unit. *Materials Today: Proceedings*, *5*(2), pp.7668-7677.

Dora, M., Kumar, M., Van Goubergen, D., Molnar, A. and Gellynck, X., 2013. Operational performance and critical success factors of lean manufacturing in European food processing SMEs. *Trends in food science & technology*, *31*(2), pp.156-164.

Dorval, M., Jobin, M.H. and Benomar, N., 2019. Lean culture: a comprehensive systematic literature review. *International Journal of Productivity and Performance Management*, *68*(5), pp.920-937.

Dragulanescu, I.V. and Popescu, D., 2015. Quality and competitiveness: a lean six sigma approach. Amfiteatru Economic Journal, 17(Special No. 9): 1167-1182.

Dramm, J., 2000. Results-driven approach to improving quality and productivity. *State & Private Forestry (undated)*, pp.1-6.

Drohomeretski, E., Gouvea da Costa, S.E., Pinheiro de Lima, E. and

Garbuio, P.A.D.R., 2014. Lean, Six Sigma and Lean Six Sigma: an analysis based on operations strategy. *International Journal of Production Research*, *52*(3), pp.804-824.

Ekolu, S.O. and Quainoo, H., 2019. Reliability of assessments in engineering education using Cronbach's alpha, KR and split-half methods. *Global journal of engineering education*, *21*(1), pp.24-29.

Elliott, M.L., Knodt, A.R., Ireland, D., Morris, M.L., Poulton, R., Ramrakha, S., Sison, M.L., Moffitt, T.E., Caspi, A. and Hariri, A.R., 2020. What is the test-retest reliability of common task-functional MRI measures? New empirical evidence and a meta-analysis. *Psychological science*, *31*(7), pp.792-806.

Elshennawy, A.K., Bahaitham, H. and Furterer, S., 2012. Assessing sustainability of lean implementation in healthcare: A case study using the lean sustainability assessment framework (LSAF). *Journal of Management & Engineering Integration*, *5*(2), p.29.

Emiliani, M.L., 2008. Lean behaviors. *Management decision*, *36*(9), pp.615-631.

Emiliani, M.L., 2015. Engaging faculty in lean teaching. *International Journal of Lean Six Sigma*, *6*(1).

Erbiyik, H. and Saru, M., 2015. Six Sigma Implementations in Supply Chain: An Application for an Automotive Subsidiary Industry in Bursa in Turkey. *Procedia-Social and Behavioral Sciences*, *195*, pp.2556-2565.

Evans, J.R. and Lindsay, W.M., 2014. *An introduction to Six Sigma and process improvement*. Cengage Learning.

Fadason, R.T., Danladi, C.Z. and Akut, K.L., 2018. Challenges Of Building Information Modelling Implementation In Africa A Case Of Nigerian Construction Industry. In *FIG Congress 2018* (Vol. 2, No. 01, pp. 1-6).

Fan, H., Chau, K.T., Liu, C., Cao, L. and Ching, T.W., 2018. Quantitative comparison of novel dual-PM linear motors for ropeless elevator system. *IEEE Transactions on Magnetics*, *54*(11), pp.1-6.

Farrukh, A., Mathrani, S. and Sajjad, A., 2022. A natural resource and institutional theory-based view of green-lean-six sigma drivers for environmental management. *Business Strategy and the Environment*, *31*(3), pp.1074-1090.

Fassoula, E.D., 2006. Transforming the supply chain. *Journal of Manufacturing Technology Management*, *17*(6), pp.848-860.

Fellows, R.F. and Liu, A.M., 2018. Where do I go from here? Motivated reasoning in construction decisions. *Construction management and economics*, *36*(11), pp.623-634.

Foster, J., Segev, D. and Maguire, J., 2014. Systematic Improvement of Fab Productivity. *Semiconductor International*, *27*(8), pp.77-81.

Fraza, C.J., 2020. The underlying brain networks of superior memory.

Frost, J., 2020. Hypothesis testing: An intuitive guide for making data driven decisions. *(No Title)*.

Frost, J., 2020. Using Histograms to Understand your Data. *Introduction to Statistics: An Intuitive Guide for Analysing Data and Unlocking Discoveries*.

Furterer, S. and Elshennawy, A.K., 2005. Implementation of TQM and lean Six Sigma tools in local government: a framework and a case study. *Total Quality Management & Business Excellence*, *16*(10), pp.1179-1191.

Gaikwad, L.M. and Sunnapwar, V., 2020. Critical success factors for implementing integrated lean green six sigma strategies: A framework. *Journal of Industrial Engineering and its Applications. 2020a*, *5*(1), pp.25-40.

Gattorna, J. and Ellis, D., 2016. The supply chains of 2030. In *Dynamic Supply Chain Alignment* (pp. 387-396). Routledge.

George Sr, M.L., Blackwell, D.K., George Jr, M.L. and Rajan, D., 2019. *Lean Six Sigma in the age of artificial intelligence: Harnessing the power of the fourth industrial revolution*. McGraw-Hill Education.

George, M.L. and George, M., 2003. *Lean six sigma for service* New York: McGraw-Hill,pp273.

Ghiani, G., Laganà, D., Manni, E., Musmanno, R. and Vigo, D., 2014. Operations research in solid waste management: A survey of strategic and tactical issues. *Computers & Operations Research*, *44*, pp.22-32.

Gholami, H., Jamil, N., Mat Saman, M.Z., Streimikiene, D., Sharif, S. and Zakuan, N., 2021. The application of green lean six sigma. *Business Strategy and the Environment*, *30*(4), pp.1913-1931.

Ghosh, S., Ma, L., Ofori-Opoku, N. and Guyer, J.E., 2017. On the primary spacing and microsegregation of cellular dendrites in laser deposited Ni–Nb alloys. *Modelling and simulation in materials science and engineering*, *25*(6), p.065002.

Gong, D.C., Chen, P.S. and Wang, S.J., 2021. SIMULATION STUDY OF IMPACT OF CAPACITY RESERVATION THRESHOLD ON ORDER FULFILMENT. *International Journal of Simulation Modelling (IJSIMM)*, *20*(1).

Goshime, Y., Kitaw, D. and Jilcha, K., 2019. Lean manufacturing as a vehicle for improving productivity and customer satisfaction: A literature review on metals and engineering industries. *International Journal of Lean Six Sigma*, *10*(2), pp.691-714.

Gross, S., Stelzl, K., Grisold, T., Mendling, J., Röglinger, M. and vom Brocke, J., 2021. The Business Process Design Space for exploring process redesign alternatives. *Business Process Management Journal*, *27*(8), pp.25-56.

Guerrero, J.E., Leavengood, S., Gutiérrez-Pulido, H., Fuentes-Talavera, F.J. and Silva-Guzmán, J.A., 2017. Applying lean six sigma in the wood furniture industry: a case study in a small company. *Quality management journal*, *24*(3), pp.6-19.

Guleria, P., Pathania, A., Sharma, S. and Sá, J.C., 2022. Lean six-sigma implementation in an automobile axle manufacturing industry: A case study. *Materials Today: Proceedings*, *50*, pp.1739-1746.

Gupta, S., Modgil, S. and Gunasekaran, A., 2020. Big data in lean six sigma: a review and further research directions. *International Journal of Production Research*, *58*(3), pp.947-969.

Gupta, S.K., Antony, J., Lacher, F. and Douglas, J., 2020. Lean Six Sigma for reducing student dropouts in higher education–an exploratory study. *Total Quality Management & Business Excellence*, *31*(1-2), pp.178-193.

Habibi, M., Kermanshachi, S. and Rouhanizadeh, B., 2019. Identifying and measuring engineering, procurement, and construction (EPC) key performance indicators and management strategies. *Infrastructures*, 4(2), p.14.

Hamilton, W.L., Ying, R. and Leskovec, J., 2017. Representation learning on graphs: Methods and applications. *arXiv preprint arXiv:1709.05584*.

Harrington Jr, J., 2020. *Understanding the manufacturing process: key to successful CAD/CAM implementation*. Crc Press.

Harry, M.J., Mann, P.S., De Hodgins, O.C., Hulbert, R.L. and Lacke, C.J., 2010. *Practitioner's guide to statistics and lean six sigma for process improvements*. John Wiley & Sons.

Hasan, R., Mitra, D. and Sundaram, A., 2013. What explains the high capital intensity of Indian manufacturing?. *Indian Growth and Development Review*, *6*(2), pp.212-241.

Hausleiter, A., al-Najem, M. and Eichmann, R., 2019. Taymāʼl: Archaeological Exploration, Palaeoenvironment, Cultural Contacts. *Taymāʼl*, pp.1-278.

Hedlund-DeWitt, N., 2013. Coding: an overview and guide to qualitative data analysis for integral researchers', IRC Resource Papers.

Henn, R., Schwab, A. and Huck, C.W., 2016. Evaluation of benchtop versus portable near-infrared spectroscopic method combined with multivariate approaches for the fast and simultaneous quantitative analysis of main sugars in syrup formulations. *Food Control*, *68*, pp.97-104.

Hines, T., 2014. *Supply chain strategies: Demand driven and customer focused*. Routledge.

Huang, J., Irfan, M., Fatima, S.S. and Shahid, R.M., 2023. The role of lean six sigma in driving sustainable manufacturing practices: an analysis of the relationship between lean six sigma principles, data-driven decision making, and environmental performance. *Frontiers in Environmental Science*, 11, p.1184488.

Huehn-Brown, W.J. and Murray, S.L., 2010. Are companies continuously improving their supply chain?. *Engineering Management Journal*, *22*(4), pp.3-10.

Hynes, J.P., Murray, A.S., Murray, O.M., Eustace, S.K., Gilchrist, S., Dolan, A. and Lawler, L.P., 2019. Use of Lean Six Sigma methodology shows reduction of inpatient waiting time for peripherally inserted central catheter placement. *Clinical radiology*, *74*(9), pp.733-e5.

Ibrahim, A.R.B., Roy, M.H., Ahmed, Z. and Imtiaz, G., 2010. An investigation of the status of the Malaysian construction industry. *Benchmarking: An International Journal*, *17*(2), pp.294-308.

Idris, M., Ugarte, M. and Vansummeren, S., 2017, May. The dynamic yannakakis algorithm: Compact and efficient query processing under updates. In *Proceedings of the 2017 ACM International Conference on Management of Data* (pp. 1259-1274).

Ingham-Broomfield, R., 2014. A nurses' guide to quantitative research. *Australian Journal of Advanced Nursing, The*, *32*(2), pp.32-38.

Ismyrlis, V. and Moschidis, O., 2015. The effects of ISO 9001 certification on the performance of Greek companies: A multidimensional statistical analysis. *The TQM journal*, *27*(1), pp.150-162.

Jadhav, A., Rahman, S. and Ahsan, K., 2022. Sustainability practices disclosure of top logistics firms in Australia. *The International Journal of Logistics Management*, *33*(5), pp.244-277.

Jasti, N.V.K. and Kodali, R., 2014. Validity and reliability of lean manufacturing frameworks. *International Journal of Lean Six Sigma*, *5*(4), p.361.

Juran, J.M. 2018. World War II and the quality movement. *Quality in higher education. Oxford: Routledge*,pp. 65.

Kamble, S., Gunasekaran, A. and Dhone, N.C., 2020. Industry 4.0 and lean manufacturing practices for sustainable organisational performance in Indian manufacturing companies. *International journal of production research*, *58*(5), pp.1319-1337.

Karthi, S., Devadasan, S., Selvaraju, K., Sreenivasa, C.G. and Sivaram, N.M., 2014. Transforming into a Lean Six Sigma enterprise through ISO 9001 standard-based quality management system. *Journal of Enterprise Transformation*, *4*(2), pp.100-122.

Kawa, A. and Zdrenka, W., 2016. Conception of integrator in cross-border e-commerce. *LogForum*, *12*(1).

Kazmi, M. and Shah, S.A.H., 2020. Six Sigma, a road to infallible service quality in hotel industry of Pakistan. *Artech J. Tour. Res. Hosp*, *1*, pp.6-12.

Khan, M., Jaber, M.Y. and Bonney, M., 2011. An economic order quantity

(EOQ) for items with imperfect quality and inspection errors. *International Journal of Production Economics*, *133*(1), pp.113-118.

Khan, M.R., Hasan, A., Ray, S.K., Saha, A. and Abdul, A.B.M., 2013. Autonomous Order Processing System for Supply Chain Management-An Initiative to Match Demand and Supply for Processed Food Industries in Bangladesh. *International Journal of Modern Engineering Research (IJMER)*, *3*(6), pp.3348-3358.

Khan, S.A.R., Dong, Q.L. and Yu, Z., 2017, September. Role of ABC Analysis in the process of efficient order fulfillment: Case study. In *Advanced Engineering Forum* (Vol. 23, pp. 114-121). Trans Tech Publications Ltd.

King, P.L. and King, J.S., 2017. *Value stream mapping for the process industries: Creating a roadmap for lean transformation*. CRC Press.

Kocaoglu, B. and Acar, A.Z., 2016. Process development in customer order information systems to gain competitive advantage: a SME case study. *International Journal of Logistics Systems and Management*, *23*(2), pp.209-230.

Kotter, J.P. 2017. *What leaders really do. In Leadership Perspectives* (pp. 7-15). London, UK: Routledge, 2017.

Kuei, C.H., Madu, C.N., Chow, W.S. and Chen, Y., 2015. Determinants and associated performance improvement of green supply chain management in China. *Journal of cleaner production*, *95*, pp.163-173.

Kuei, C.H., Madu, C.N. and Lin, C., 2011. Developing global supply chain quality management systems. *International Journal of Production Research*, *49*(15), pp.4457-4481.

Kumar, S., Kumar, N. and Haleem, A., 2015. Conceptualisation of sustainable green lean six sigma: an empirical analysis. *International Journal of Business Excellence*, *8*(2), pp.210-250.

Kumar, S., Brahma, G., Kaur, P. and Gupta, B.K., 2020. A case study on quality improvement of connecting rod assembly line using Six Sigma DMAIC cycle. *International Journal of Six Sigma and Competitive Advantage*, *12*(2-3), pp.234-249.

Kumar, P., Singh, D. and Bhamu, J., 2021. Development and validation of DMAIC based framework for process improvement: a case study of

Indian manufacturing organisation. *International Journal of Quality & Reliability Management*, *38*(9), pp.1964-1991.

Kumari, R., Quazi, T.Z. and Kumar, R., 2015. Application of lean manufacturing tools in garment industry. *International Journal Of Mechanical Engineering And Information Technology*, *3*(1), pp.976-982.

LaLonde, R. and Bagci, U., 2018. Capsules for object segmentation. *arXiv preprint arXiv:1804.04241*.

Lancaster, K., 2017. Confidentiality, anonymity and power relations in elite interviewing: conducting qualitative policy research in a politicised domain. *International Journal of Social Research Methodology*, *20*(1), pp.93-103.

Laureani, A. and Antony, J., 2017. Leadership characteristics for lean six sigma. *Total Quality Management & Business Excellence*, *28*(3-4), pp.405-426.

Laureani, A. and Antony, J., 2019. Leadership and Lean Six Sigma: a systematic literature review. *Total Quality Management & Business Excellence*, *30*(1-2), pp.53-81.

Leke, C.A. and Marwala, T., 2019. *Deep learning and missing data in engineering systems* (p. 179). Berlin, Germany: Springer International Publishing.

Leung, K. H., Stephen WY Cheng, K. L. Choy, David WC Wong, H. Y. Lam, Yasmin YY Hui, Yung Po Tsang, and Valerie Tang. "A process-oriented warehouse postponement strategy for e-commerce order fulfillment in warehouses and distribution centers in Asia." In *Managerial strategies and solutions for business success in asia*, pp. 21-34. IGI Global, 2017.

Leyer, M., Reus, M. and Moormann, J., 2021. How satisfied are employees with lean environments?. *Production Planning & Control*, *32*(1), pp.52-62.

Li, N., Laux, C.M. and Antony, J., 2019. How to use lean Six Sigma methodology to improve service process in higher education: A case study. *International Journal of Lean Six Sigma*, *10*(4), pp.883-908.

Liker, J.K., Hoseus, M. and Center for Quality People and Organisations, 2008. *Toyota culture*. New York: McGraw-Hill Publishing.

Lim, M.K., Lai, M., Wang, C. and Lee, Y., 2022. Circular economy to ensure production operational sustainability: A green-lean approach. *Sustainable Production and Consumption*, *30*, pp.130-144.

Liu, Qian, and Garrett Van Ryzin. "On the choice-based linear programming model for network revenue management." *Manufacturing & Service Operations Management* 10, no. 2 (2008): 288-310.

Liu, Q. and Van Ryzin, G.J., 2008. Strategic capacity rationing to induce early purchases. *Management Science*, *54*(6), pp.1115-1131.

Losonci, D., Demeter, K. and Jenei, I., 2011. Factors influencing employee perceptions in lean transformations. *International Journal of Production Economics*, *131*(1), pp.30-43.

Mabotja, T.P., Mulongo, N.Y. and Kholopane, P.A., 2018. A theoretical assessment of Warehouse Performance in Manufacturing Industries. In *International Conference on Industrial Engineering and Operations Management*.

Machado Fagundes da Silva, T., Costa Santos, L. and Fabiana Gohr, C., 2022. Exploring risks in lean production implementation: systematic literature review and classification framework. *International Journal of Lean Six Sigma*, *13*(2), pp.474-501.

Mackay, C., 2021. NAACAM, members demonstrate innovation, resilience in challenging year. *Engineering News*.

Madhani, P.M., 2018. Lean Six Sigma deployment in BFSI sector: synthesising and developing customer value creation models. *International Journal of Electronic Customer Relationship Management*, *11*(3), pp.272-314.

Maged, A., Haridy, S., Kaytbay, S. and Bhuiyan, N., 2019. Continuous improvement of injection moulding using Six Sigma: case study. *International Journal of Industrial and Systems Engineering*, *32*(2), pp.243-266.

Madsen, D.Ø., Risvik, S. and Stenheim, T., 2017. The diffusion of Lean in the Norwegian municipality sector: An exploratory survey. *Cogent business & management*, *4*(1), p.1411067.

Mahomed, H. and Peters, B., 2011. The story behind the well: A case study of successful community development in Makutano, Kenya.

Marley, K.A. and Ward, P.T., 2013. Lean management as a countermeasure for “Normal” disruptions. *Operations Management Research*, *6*, pp.44-52.

Marodin, G.A. and Saurin, T.A., 2015. Classification and relationships between risks that affect lean production implementation: a study in Southern Brazil. *Journal of Manufacturing Technology Management*, *26*(1), pp.57-79.

Marsillac, E. and Roh, J.J., 2014. Connecting product design, process and supply chain decisions to strengthen global supply chain capabilities. *International Journal of Production Economics*, *147*, pp.317-329.

Martin, W.E. and Bridgmon, K.D., 2012. *Quantitative and statistical research methods: From hypothesis to results*. John Wiley & Sons.

Martin, J.W., 2014. *Lean Six Sigma for supply chain management: A 10-step solution process*. McGraw-Hill Education.

Martínez-Costa, M., Martínez-Lorente, A.R. and Choi, T.Y., 2008. Simultaneous consideration of TQM and ISO 9000 on performance and motivation: An empirical study of Spanish companies. *International journal of production economics*, *113*(1), pp.23-39.

Maxwell, J.A., 2019. Distinguishing between quantitative and qualitative research: A response to Morgan. *Journal of mixed methods research*, *13*(2), pp.132-137.

McLean, R. and Antony, J., 2014. Why continuous improvement initiatives fail in manufacturing environments? A systematic review of the evidence. *International Journal of Productivity and Performance Management*, *63*(3), pp.370-376.

McLean, R.S., Antony, J. and Dahlgaard, J.J., 2017. Failure of Continuous Improvement initiatives in manufacturing environments: a systematic review of the evidence. *Total Quality Management & Business Excellence*, *28*(3-4), pp.219-237.

Miller, C., Shapiro, K., Luck, S. 2012. The effect of competition on early visual ERP components. Journal of Vision. 12(9): 376-376.

Mohajan, H.K., 2020. Quantitative research: A successful investigation in natural and social sciences. *Journal of Economic Development, Environment and People*, *9*(4), pp.50-79.

Moser, P., Isaksson, O. and Seifert, R., 2017. How process industries can improve supply chain performance. *CSCMP's Supply Chain Quarterly*, (3).

Muganyi, P., Madanhire, I. and Mbohwa, C., 2018. Business survival and market performance through Lean Six Sigma in the chemical manufacturing industry. *International Journal of Lean Six Sigma*, *10*(2), pp.566-600.

Muijs, D., 2010. Doing quantitative research in education with SPSS. *Doing quantitative research in education with SPSS*, pp.1-264.

Murphy, J., Fu, K., Otto, K., Yang, M., Jensen, D. and Wood, K., 2014. Function based design-by-analogy: a functional vector approach to analogical search. *Journal of Mechanical Design*, *136*(10), p.101102.

Munir, M. and Arifin, S., 2021. Organisational Culture and Impact on Improving Employee Performance. *Journal of Social Science Studies (JOS3)*, *1*(2), pp.65-68.

Munyai, T.T., Mbonyane, B.L. and Mbohwa, C., 2017. *Productivity improvement in manufacturing SMEs: Application of work study*. CRC Press.

Munyai, T., Mbohwa, C., Makinde, O.A. and Ramatsetse, B.I., 2017, December. A system model to improve the productivity of a South African steel industry. In *2017 IEEE International Conference on Industrial Engineering and Engineering Management (IEEM)* (pp. 329-333). IEEE.

Mwacharo, F., 2013. Challenges of Lean Management: Investigating the challenges and developing a recommendation for implementing Lean management techniques.

Mahalik, N.P. and Nambiar, A.N., 2010. Trends in food packaging and manufacturing systems and technology. *Trends in food science & technology*, *21*(3), pp.117-128.

Nandakumar, N., Saleeshya, P.G. and Harikumar, P., 2020. Bottleneck identification and process improvement by lean six sigma DMAIC methodology. *Materials Today: Proceedings*, *24*, pp.1217-1224.

Narula, V. and Grover, S., 2015. Six Sigma: literature Review and Implications for future research. *International Journal of Industrial Engineering*, *26*(1), pp.13-26.

Naude, M.J. and Badenhorst-Weiss, J.A., 2011. Supply chain management problems at South African automotive component manufacturers. *Southern African Business Review*, *15*(1).

Ndaita, P.M., Gachie, T. and Kiveu, C.W., 2015. The implementation of Lean Six Sigma concept at national bank of Kenya-operation division. *The TQM Journal*, *27*(6), pp.683-690.

Ng, K.C., Chong, K.E. and Goh, G.G.G., 2014, December. Improving Overall Equipment Effectiveness (OEE) through the six sigma methodology in a semiconductor firm: A case study. In *2014 IEEE International conference on industrial engineering and engineering management* (pp. 833-837). IEEE.

Nunes, I.L., 2015. Integration of ergonomics and lean six sigma. A model proposal. *Procedia Manufacturing*, *3*, pp.890-897.

Klein, L.L., Vieira, K.M., Feltrin, T.S., Pissutti, M. and Ercolani, L.D., 2022. The influence of lean management practices on process effectiveness: a quantitative study in a public institution. *Sage Open*, *12*(1), p.21582440221088837.

Odediran, S.J., Adeyinka, B.F., Opatunji, O.A. and Morakinyo, K.O., 2012. Business structure of indigenous firms in the Nigerian construction industry. *International Journal of Business Research and Management*, *3*(5), pp.255-264.

Ofori, G., 2000. Greening the construction supply chain in Singapore. *European Journal of Purchasing & Supply Management*, *6*(3-4), pp.195-206.

Ofori, D.F. and Hinson, R.E., 2007. Corporate social responsibility (CSR) perspectives of leading firms in Ghana. *Corporate Governance: The international journal of business in society*, *7*(2), pp.178-193.

Olanrewaju, F., Chima Uzorh, A. and Nnanna, I., 2019. Lean Six Sigma Methodology and Its Application in the Manufacturing Industry–A Review. *American Journal of Mechanical and Industrial Engineering*, *4*(3), p.40.

Pagani, P., Abimiku, Y. and Emeka-Okolie, W., 2008. Assessment of the Nigerian poultry market chain to improve biosecurity. *FAO (Nigeria, Consultative Mission on Poultry) Study*, pp.1-65.

Pallant, J., 2020. *SPSS survival manual: A step by step guide to data* *analysis using IBM SPSS*. McGraw-hill education (UK).

Pamfilie, R., Petcu, A.J. and Draghici, M., 2012. The importance of leadership in driving a strategic Lean Six Sigma management. *Procedia-Social and Behavioral Sciences*, *58*, pp.187-196.

Pandey, H., Garg, D. and Luthra, S., 2018. Identification and ranking of enablers of green lean Six Sigma implementation using AHP. *International Journal of Productivity and Quality Management*, *23*(2), pp.187-217.

Patel, A., D'Alessandro, M.M., Ireland, K.J., Burel, W.G., Wencil, E.B. and Rasmussen, S.A., 2017. Personal protective equipment supply chain: lessons learned from recent public health emergency responses. *Health security*, *15*(3), pp.244-252.

Pathiratne, S.U., Khatibi, A. and Md Johar, M.G., 2018. CSFs for Six Sigma in service and manufacturing companies: an insight on literature. *International Journal of Lean Six Sigma*, *9*(4), pp.543-561.

Paul, G., Röger, G., Keller, T. and Helmert, M., 2017. Optimal Solutions to Large Logistics Planning Domain Problems. In *Proceedings of the International Symposium on Combinatorial Search* (Vol. 8, No. 1, pp. 73-81).

Pekeur, S.W., 2002. *Assessing diversity awareness of local Government managers* (Doctoral dissertation, Cape Technikon).

Pereira, A.M., Silva, M.R., Domingues, M.A. and Sá, J.C., 2019. Lean six sigma approach to improve the production process in the mould industry: A case study. *Quality Innovation Prosperity*, *23*(3), pp.103-121.

Petnikota, S., Marka, S.K., Banerjee, A., Reddy, M.V., Srikanth, V.V.S.S. and Chowdari, B.V.R., 2015. Graphenothermal reduction synthesis of 'exfoliated graphene oxide/iron (II) oxide'composite for anode application in lithium ion batteries. *Journal of Power Sources*, *293*, pp.253-263.

Poortinga, A., Tenneson, K., Shapiro, A., Nquyen, Q., San Aung, K., Chishtie, F. and Saah, D., 2019. Mapping plantations in Myanmar by fusing Landsat-8, Sentinel-2 and Sentinel-1 data along with systematic error quantification. *Remote sensing*, *11*(7), p.831.

Prado-Prado, J.C., García-Arca, J., Fernández-González, A.J. and Mosteiro-Añón, M., 2020. Increasing competitiveness through the implementation of lean management in healthcare. *International Journal of Environmental Research and Public Health*, *17*(14), p.4981.

Psomas, E.L., Pantouvakis, A. and Kafetzopoulos, D.P., 2013. The impact of ISO 9001 effectiveness on the performance of service companies. *Managing Service Quality: An International Journal*, *23*(2), pp.149-164.

Ptacek, R., Sperl, T. and Trewn, J., 2015. The Practical Lean Six Sigma Pocket Guide: Using the A3 and Lean Thinking to Improve Operational Performance in Any Industry. *Any Time,*, pp.5-288.

Puvanasvaran, A. P., S. S. Yoong, and C. C. Tay. "New Overall Equipment Effectiveness framework development with integration of Maynard Operation Sequence Technique." *ARPN Journal of Engineering and Applied Sciences* 14, no. 20 (2019): 3600-3608.

Rahmadi, I. and Bernik, M., 2018. Penerapan Lean Six Sigma Pada Ukm Untuk Meningkatkan Kualitas Produk Pendukung Perangkat Telekomunikasi. *ISEI Business and Management Review*, *2*(1), pp.9-24.

Raja Sreedharan, V. and Raju, R.J.I.J., 2016. A systematic literature review of Lean Six Sigma in different industries. *International Journal of Lean Six Sigma*, *7*(4), pp.430-466.Rameni, A. and Banuelos, R., 2018. DMAIC Approach to Address Non-Compliances in 3D Features Based Computer Generated Design Model. In *Proceeding of International Conference of Industrial Engineering and Operation Management. Pretoria South Africa*.

Ranjan, S., Jha, V.K. and Pal, P., 2017. Application of emerging technologies in ERP implementation in Indian manufacturing enterprises: an exploratory analysis of strategic benefits. *The International Journal of Advanced Manufacturing Technology*, *88*, pp.369-380.

Rashid, O.A. and Ahmad, M.N., 2013. Business process improvement methodologies: an overview. *Journal of Information System Research Innovation*, *5*, pp.45-53.

Rathilall, R., Singh, S. 2018. A Lean Six-sigma framework to enhance the competitiveness in selected automotive component manufacturing organisations. *South African journal of economic and management sciences.* 21(1): 1-13.

Raval, S.J., Kant, R. and Shankar, R., 2019. Benchmarking the Lean Six Sigma performance measures: a balanced score card approach. *Benchmarking: An International Journal*, *26*(6), pp.1921-1947.

Razali, N.M. and Wah, Y.B., 2011. Power comparisons of shapiro-wilk, kolmogorov-smirnov, lilliefors and anderson-darling tests. *Journal of statistical modeling and analytics*, *2*(1), pp.21-33.

Roriz, C., E. Nunes, and Sérgio Sousa. "Application of lean production principles and tools for quality improvement of production processes in a carton company." *Procedia manufacturing* 11 (2017): 1069-1076.

Roy, S.K., Balaji, M.S., Quazi, A. and Quaddus, M., 2018. Predictors of customer acceptance of and resistance to smart technologies in the retail sector. *Journal of Retailing and Consumer Services*, *42*, pp.147-160.

Sabale, S. and Thorat, S., 2019. Applications of Lean Six Sigma.

Siebra, C.A., Costa, P.H., Santos, A.L. and Silva, F.Q., 2017, May. Improving the handsets network test process via DMAIC concepts. In *Proceedings of the 30th international conference on Software engineering* (pp. 733-740).

Saha, S., 2013. Supply chain coordination through rebate induced contracts. *Transportation Research Part E: Logistics and Transportation Review*, *50*, pp.120-137.

Mitrogogos, K. and Saidul Huq, K.M., 2018. Impact of lean manufacturing on process industries.

Sahoo, S., 2020. Assessing lean implementation and benefits within Indian automotive component manufacturing SMEs. *Benchmarking: An International Journal*, *27*(3), pp.1042-1084.

Salah, S., Rahim, A. and Carretero, J.A., 2010. The integration of Six Sigma and lean management. *International journal of lean Six Sigma*, *1*(3), pp.249-274.

Santos, G., Afonseca, J., Lopes, N., Félix, M.J. and Murmura, F., 2018. Critical success factors in the management of ideas as an essential component of innovation and business excellence. *International Journal of Quality and Service Sciences*, *10*(3), pp.214-232.

Sardroud, J.M., 2012. Influence of RFID technology on automated management of construction materials and components. *Scientia Iranica*, *19*(3), pp.381-392.

Satoglu, S., Ustundag, A., Cevikcan, E. and Durmusoglu, M.B., 2018. Lean transformation integrated with Industry 4.0 implementation methodology. In *Industrial Engineering in the Industry 4.0 Era: Selected papers from the Global Joint Conference on Industrial Engineering and Its Application Areas, GJCIE 2017, July 20–21, Vienna, Austria* (pp. 97-107). Springer International Publishing.

Scala, A., Ponsiglione, A.M., Loperto, I., Della Vecchia, A., Borrelli, A., Russo, G., Triassi, M. and Improta, G., 2021. Lean six sigma approach for reducing length of hospital stay for patients with femur fracture in a university hospital. *International Journal of Environmental Research and Public Health*, *18*(6), p.2843.

Schwab, K., 2019, December. The global competitiveness report 2019. In *World Economic Forum* (Vol. 9, No. 10).

Shah, Rachna, and Peter T. Ward. "Defining and developing measures of lean production." *Journal of operations management* 25, no. 4 (2007): 785-805.

Shah, S.A., Asif, M.A., Shoukat, M.H., Polatci, S. and Rehman, S.U., 2022. Quality management practices and inter-organisational project performance: Moderating effects of inter-organisational communication, relationship, and process conflicts in healthcare. *Sage Open*, *12*(3), p.21582440221113829.

Sharma, P., Malik, S.C., Gupta, A. and Jha, P.C., 2018. A DMAIC Six Sigma approach to quality improvement in the anodising stage of the amplifier production process. *International Journal of Quality & Reliability Management*, *35*(9), pp.1868-1880.

Shazali, N.A., Habidin, N.F., Ali, N., Khaidir, N.A. and Jamaludin, N.H., 2013. Lean healthcare practice and healthcare performance in Malaysian healthcare industry. *International Journal of Scientific and Research Publications*, *3*(1), pp.1-5.

Shen, W., Tang, W., Yu, W., Duffield, C.F., Hui, F.K.P., Wei, Y. and Fang, J.,

2017. Causes of contractors' claims in international engineering-procurement-construction projects. *Journal of civil engineering and management*, *23*(6), pp.727-739.

Shook, J., 2010. How to change a culture: Lessons from NUMMI. *MIT Sloan Management Review*.

Sibalija, T. and Vidosav, M., 2014. Integrating Lean with/within Six Sigma. *International Journal'Total Quality Management & Excellence*, *38*(4).

Sibalija, T.V. and Majstorovic, V.D., 2012. An integrated approach to optimise parameter design of multi-response processes based on Taguchi method and artificial intelligence. *Journal of Intelligent manufacturing*, *23*, pp.1511-1528.

Silverman, D., 2013. *A very short, fairly interesting and reasonably cheap book about qualitative research*. Sage.

Sin, A.B., Zailani, S., Iranmanesh, M. and Ramayah, T., 2015. Structural equation modelling on knowledge creation in Six Sigma DMAIC project and its impact on organisational performance. *International Journal of Production Economics*, *168*, pp.105-117.

Singh, J., Singh, H., Singh, A. and Singh, J., 2020. Managing industrial operations by lean thinking using value stream mapping and six sigma in manufacturing unit: Case studies. *Management decision*, *58*(6), pp.1118-1148.

Singh, M., Rathi, R. and Garza-Reyes, J.A., 2021. Analysis and prioritization of Lean Six Sigma enablers with environmental facets using best worst method: A case of Indian MSMEs. *Journal of cleaner production*, *279*, p.123592.

Singh, S., 2011. An integrative approach to management systems and business excellence. *African journal of business management*, *5*(5), pp.1618-1629.

Smętkowska, M. and Mrugalska, B., 2018. Using Six Sigma DMAIC to improve the quality of the production process: a case study. *Procedia-Social and Behavioral Sciences*, *238*, pp.590-596.

Sokovic, M., Pavletic, D. and Pipan, K.K., 2010. Quality improvement methodologies–PDCA cycle, RADAR matrix, DMAIC and DFSS. *Journal of achievements in materials and manufacturing* *engineering*, *43*(1), pp.476-483.

Son, B.Y. and Lee, E.B., 2019. Using text mining to estimate schedule delay risk of 13 offshore oil and gas EPC case studies during the bidding process. *Energies*, *12*(10), p.1956.

Sreedharan V, R., V, G., Nair, S., Chakraborty, A. and Antony, J., 2018. Assessment of critical failure factors (CFFs) of Lean Six Sigma in real life scenario: evidence from manufacturing and service industries. *Benchmarking: An International Journal*, *25*(8), pp.3320-3336.

Sreedharan V, R. and Sunder M, V., 2018. A novel approach to lean six sigma project management: a conceptual framework and empirical application. *Production Planning & Control*, *29*(11), pp.895-907.

Stamatis, D.H., 2019. *Six Sigma fundamentals: A complete introduction to the system, methods, and tools*. CRC Press.

Starbird, D. and Cavanagh, R.R., 2010. *Building engaged team performance: Align your processes and people to achieve game-changing business results*. McGraw Hill Professional.

Stern, N., 2016. Economics: Current climate models are grossly misleading. *Nature*, *530*(7591), pp.407-409.

Steward, J.H., 2015. The concept and method of cultural ecology. *Anthropology in theory: Issues in Epistemology*, pp.100-106.

Sunder M, V., Mahalingam, S. and Krishna M, S.N., 2020. Improving patients' satisfaction in a mobile hospital using Lean Six Sigma–a design-thinking intervention. *Production Planning & Control*, *31*(6), pp.512-526.

Tafazzoli, M. and Shrestha, P., 2017, October. Factor analysis of construction delays in the US construction industry. In *International conference on sustainable infrastructure* (pp. 111-122).

Talankar, A., Verma, P. and Seth, N., 2015. Modelling the clusters of critical success factors of Six Sigma for non-formal service sectors using interpretive structural modelling. *International Journal of Six Sigma and Competitive Advantage*, *9*(2-4), pp.222-240.

Tampubolon, S., Purba, H.H. 2021. Lean six sigma implementation: a systematic literature review. International Journal of Production

Management and Engineering. 9(2): 125-139.

Teddlie, C. and Tashakkori, A., 2010. Overview of contemporary issues in mixed methods research. *Sage handbook of mixed methods in social and behavioral research*, *2*, pp.1-44.

Teddlie, C. and Yu, F., 2017. Mixed methods sampling: A typology with examples. *Journal of mixed methods research*, *1*(1), pp.77-100.

Teng, H.S.S., 2014. Qualitative productivity analysis: does a non-financial measurement model exist?. *International Journal of Productivity and performance management*, *63*(2), pp.250-256.

Thomas, A.J., Francis, M., Fisher, R. and Byard, P., 2016. Implementing Lean Six Sigma to overcome the production challenges in an aerospace company. *Production Planning & Control*, *27*(7-8), pp.591-603.

Thompson, S.K., 2012. *Sampling* (Vol. 755). John Wiley & Sons.

Timans, W., Antony, J., Ahaus, K. and van Solingen, R., 2012. Implementation of Lean Six Sigma in small-and medium-sized manufacturing enterprises in the Netherlands. *Journal of the Operational Research Society*, *63*(3), pp.339-353.

Titmarsh, R., Assad, F. and Harrison, R., 2020. Contributions of lean six sigma to sustainable manufacturing requirements: an Industry 4.0 perspective. *Procedia Cirp*, *90*, pp.589-593.

Tohidi, H. and KhedriLiraviasl, K., 2012. Six sigma methodology and its relationship with lean manufacturing system. *Advances in Environmental Biology*, *6*(2), pp.895-906.

Tripathi, V., Chattopadhyaya, S., Mukhopadhyay, A.K., Sharma, S., Singh, J., Pimenov, D.Y. and Giasin, K., 2021. An innovative agile model of smart lean–green approach for sustainability enhancement in Industry 4.0. *Journal of Open Innovation: Technology, Market, and Complexity*, *7*(4), p.215.

Turesky, E.F. and Connell, P., 2010. Off the rails: understanding the derailment of a lean manufacturing initiative. *Organisation Management Journal*, *7*(2), pp.110-132.

Udokporo, C.K., Anosike, A., Lim, M., Nadeem, S.P., Garza-Reyes, J.A. and Ogbuka, C.P., 2020. Impact of Lean, Agile and Green (LAG) on business competitiveness: An empirical study of fast moving consumer goods businesses. *Resources, Conservation and Recycling*, *156*, p.104714.

Jasti, N.V.K. and Kodali, R., 2014. Validity and reliability of lean manufacturing frameworks. *International Journal of Lean Six Sigma*, *5*(4), p.361.

Van den Berg, A. and Struwig, M., 2017. Guidelines for researchers using an adapted consensual qualitative research approach in management research. *Electronic Journal of Business Research Methods*, *15*(2), pp.pp109-119.

Venkataraman, R.R. and Pinto, J.K., 2016. *Operations management: Managing global supply chains*. Sage Publications.

Wang, P., Wu, P., Chi, H.L. and Li, X., 2020. Adopting lean thinking in virtual reality-based personalised operation training using value stream mapping. *Automation in Construction*, *119*, p.103355.

Wu, W.Q., Lei, B.X., Rao, H.S., Xu, Y.F., Wang, Y.F., Su, C.Y. and Kuang, D.B., 2013. Hydrothermal fabrication of hierarchically anatase TiO2 nanowire arrays on FTO glass for dye-sensitised solar cells. *Scientific reports*, *3*(1), p.1352.

Yadav, V., Gahlot, P., Rathi, R., Yadav, G., Kumar, A. and Kaswan, M.S., 2021. Integral measures and framework for green lean six sigma implementation in manufacturing environment. *International Journal of Sustainable Engineering*, *14*(6), pp.1319-1331.

Yadav, V., Jain, R., Mittal, M.L., Panwar, A. and Sharma, M.K., 2019. An appraisal on barriers to implement lean in SMEs. *Journal of Manufacturing Technology Management*, *30*(1), pp.195-212.

Yadav, G., Luthra, S., Huisingh, D., Mangla, S.K., Narkhede, B.E. and Liu, Y., 2020. Development of a lean manufacturing framework to enhance its adoption within manufacturing companies in developing economies. *Journal of Cleaner Production*, *245*, p.118726.

Yakout, M., Elbestawi, M.A. and Veldhuis, S.C., 2018. A review of metal additive manufacturing technologies. *Solid State Phenomena*, *278*, pp.1-14.

Yanamandra, R. and Alzoubi, H.M., 2022. Empirical investigation of mediating role of six sigma approach in rationalizing the COQ in service organisations. *Operations and Supply Chain Management: An International Journal*, *15*(1), pp.122-135.

Yeh, S.T., Arthaud-Day, M. and Turvey-Welch, M., 2021. Propagation of lean thinking in academic libraries. *The Journal of Academic Librarianship*, *47*(3), p.102357.

Yilmaz, A., Dora, M., Hezarkhani, B. and Kumar, M., 2022. Lean and industry 4.0: Mapping determinants and barriers from a social, environmental, and operational perspective. *Technological Forecasting and Social Change*, *175*, p.121320.

Yuik, C.J. and Puvanasvaran, P., 2020. Development of lean manufacturing implementation framework in machinery and equipment SMEs. *International Journal of Industrial Engineering and Management*, *11*(3), p.157.

Yousefi Nooraie, R., Sale, J.E., Marin, A. and Ross, L.E., 2020. Social network analysis: An example of fusion between quantitative and qualitative methods. *Journal of Mixed Methods Research*, *14*(1), pp.110-124.

Zakuan, N.M., Yusof, S.M., Laosirihongthong, T. and Shaharoun, A.M., 2010. Proposed relationship of TQM and organisational performance using structured equation modelling. *Total quality management*, *21*(2), pp.185-203.

Zhang, M., Mezzavilla, M., Zhu, J., Rangan, S. and Panwar, S., 2017, July. TCP dynamics over mmWave links. In *2017 IEEE 18th International Workshop on Signal Processing Advances in Wireless Communications (SPAWC)* (pp. 1-6). IEEE.

APPENDIX 1: LETTER OF INVITATION FOR RESEARCH SURVEY

TO WHOM IT MAY CONCERN

Dear Sir/Madam,

LETTER OF INVITATION FOR RESEARCH SURVEY

The Department of Graduate Centre for Management is currently undertaking a research entitled: Effect of Lean Six Sigma on Operational Performance: A Comparative study in manufacturing and Service firms in South Africa. Therefore, we kindly request that you complete the following short questionnaire survey.

To protect your anonymity, please do not enter your name or contact details on the questionnaire. Your participation is voluntary, and you can withdraw at any time without penalty. Your privacy will be protected throughout the survey and your participation will remain confidential.

Responses will be analysed individually and will only be reported in aggregated form to protect and guarantee your anonymity. There will be no mention of your name or institution. Raw data will be stored in the personal computer of the principal researcher for the duration of the study, and thereafter deleted. Both storage locations are password protected. As part of the housing response research, raw data will be aggregated in a manner that ensures no linkage to individual research participants. The aggregated data will be stored in a secure cloud storage server. The aggregated data will be used for academic purposes only.

If you agree to participate, please complete the survey that follows this cover letter. By completing the survey, you indicate that you voluntarily participate in this research. The survey should take 20 minutes of your time. If you have any concerns, please contact us with the details provided below. By continuing with the survey, you indicate that:

You have read and understood the information provided above.

You give your consent to participate in the study on a voluntary basis

Yours sincerely

Vuyokazi Maku

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APPENDIX 2: SURVEY QUESTIONNAIRE

Please answer the following questions by crossing (x) the relevant block or writing down your answer in the space provided.

SECTION A: BIOGRAPHICAL DATA

1. What is your Gender?

1	Male	
2	Female	

2. In which age group do you fall?

1	Less than 20 years old	
2	20-25 years old	
3	26-35 years old	
4	36-45 years old	
5	46-55 years old	
6	More than 55 years old	

3. What is your highest qualification?

1	High school, no diploma	
2	High school graduate	
3	Diploma	
4	Bachelor's Degree/BTech	
5	Master's Degree	
6	Doctorate	
7	Others (Please indicate)	

4. What is your ethnicity?

1	Indian/ Asian	
2	Colored	
3	White	
4	African	
5	Prefer not to be classified	

5. Indicate the number of years (yrs) you have been in the manufacturing industry.

1	2	3	4	5	6	7
Less 5 yrs	5 – 10 yrs	11 – 15 yrs	16 – 20 yrs	21 – 25 yrs	26 – 30 yrs	Over 30 yrs

6. State the number of steel production projects you have been involved in.

1	2	3	4	5	6	7
None	1 – 2	3 – 4	5 – 6	7 – 8	9 – 10	More than 10

SECTION B: ORDER PROCESSING DELAYS AND BENEFITS OF LEAN SIX SIGMA (OPDBLSS)

To what extent do you agree with the following statements?

1	2	3	4	5
Strongly Disagree	Disagree	Not Sure	Agree	Strongly Agree

(Tick the appropriate number to indicate your best judgement)

Statements below can be used to assess the delays of processing orders						
OPD1	The current order process is effective	1	2	3	4	5
OPD2	The production space is effectively designed	1	2	3	4	5
OPD3	Planning staff is trained.	1	2	3	4	5
OPD4	Manufacturing staff is engaged	1	2	3	4	5
OPD5	The current order processing system is customer orientated	1	2	3	4	5
OPD6	Production process is designed for unexpected demand or peak season	1	2	3	4	5
OPD7	Current order process system benefits the customer.	1	2	3	4	5
OPD8	The improved operational processes instils customer confidence	1	2	3	4	5
OPD9	The improved manufacturing processes handle customers' problem and provide services right at the first time	1	2	3	4	5
OPD10	The improved operational processes provide prompt service to customer	1	2	3	4	5

SECTION C: LEAN SIX SIGMA PERFOMANCE INDICATOR (LSSPI)

To what extent do you agree with the following statements regarding how well the company is performing on this indicator?

1	2	3	4	5
Strongly Disagree	Disagree	Not Sure	Agree	Strongly Agree

Tick the appropriate number to indicate your best judgement)

How well is company performing on this?					**Statement**	How influential is LSPI increase productivity in your company				
1	2	3	4	5	Investing in skills development.	1	2	3	4	5
					Investing in knowledge transfer.					
					Investing in training.					
					Motivation level of employees.					
					Level of education of employees.					
					Experience level of employees.					
					Ability of the business to reduce costs.					
					Access to finance.					
					Ability of the business to remove bottlenecks.					
					Extent to which plant machinery is used to full capacity.					
					Ability to the business to adhere to scheduled maintenance of machinery.					
					Availability of machine parts when needed for breakdown repairs.					
					Availability of manufacturing tools.					
					Extent to which customer return are kept to a minimum level.					
					Extent to which customer complaints are kept to a minimum level.					
					Use of material handling equipment.					
					Frequency of quality housekeeping.					
					Extent to which floor plan design supports manufacturing.					
					Extent to which the plant layout promotes efficiency.					
					Extent to which the company provides a safe and healthy working environment.					
					Competitiveness of employees' salaries (relative to competitors).					
					Relationship between targets and incentive rewards.					
					Ability of the company to adapt to current technology.					
					Use of the latest manufacturing plant by employees.					
					Accessibility of manufacturing tools.					
					Frequency and quality of communication between workstations.					

Thank you for your contribution. We really value your contribution and time spent on completing this questionnaire