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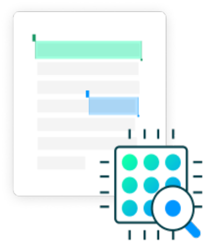

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REDUCTION OF PRODUCTION/PROCESSING TIME IN THE MANUFACTURING SECTOR THROUGH THE APPLICATION OF PROJECT MANAGEMENT TECHNIQUES

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CHAPTER ONE

INTRODUCTION

1.1 Background to the Study

The manufacturing sector remains the biggest economic development and industrialization driver, contributing significantly to GDP, employment, and technological advancement globally (Naudé & Szirmai, 2012). In 2022, the manufacturing sector added a significant 2.79 trillion U.S. dollars to the GDP of the United States. Compared to the global economic landscape, only seven countries- China, Japan, Germany, India, the United Kingdom, France, and the United States—surpass the U.S. manufacturing sector in GDP contributions. However, the sector often faces persistent challenges, including inefficiencies in production and processing times, which can lead to increased costs, reduced competitiveness, and lower profitability (Quiroz-Flores, & Vega-Alvites,, 2022). The application of project management techniques offers a viable solution to these challenges, potentially transforming production processes through improved planning, execution, and control mechanisms.

Over the years, various companies within the manufacturing industry have used project management to monitor their production activities and oversee specific projects they embark upon (Pozzi et al., 2023). These projects may be the improvement or optimization of their sophisticated machinery, the enhancement of their production line efficiency, updating existing processes or technologies used for production or establishment a new production plant. The result of this is the improvement and optimized performance of the manufacturing output of the company, and this manufacturing efficiency is paramount for maintaining competitive advantage in a globalized market (Palange & Dhatrack, 2021).

However, Achieng (2021) posited that despite advancements in technology and automation, the average production cycle time in manufacturing has not significantly decreased over the past decade, underscoring a critical area for improvement. This stagnation can be attributed to several factors, including inadequate implementation of advanced methodologies, resistance to change, and the complexity of integrating new processes into existing systems (Schemel, 2021). Moreover, inefficiencies often arise from poor planning, inadequate resource allocation, and suboptimal execution strategies, which inflate production costs and extend lead times, thereby affecting the overall supply chain performance (Khan et al., 2022).

A pertinent example is Toyota, a company renowned for its Lean manufacturing system, which has set global benchmarks for efficiency and productivity. Toyota's Lean manufacturing system, often referred to as the Toyota Production System (TPS), has long stood as a paradigm of efficiency and operational excellence within the manufacturing sector. At its core, TPS is dedicated to the relentless elimination of waste, the enhancement of product flow, and the continuous improvement of overall quality. This philosophy, deeply rooted in the Japanese concept of Kaizen, promotes ongoing, incremental improvements across all facets of the production process. By rigorously identifying and eliminating non-value-adding activities, Toyota has managed to significantly streamline its operations. This meticulous focus on waste reduction allows the company to maintain exceptionally low inventory levels, adhering to just-in-time principles that ensure materials and components are available precisely when needed, thereby minimizing storage costs and reducing the risk of excess inventory.

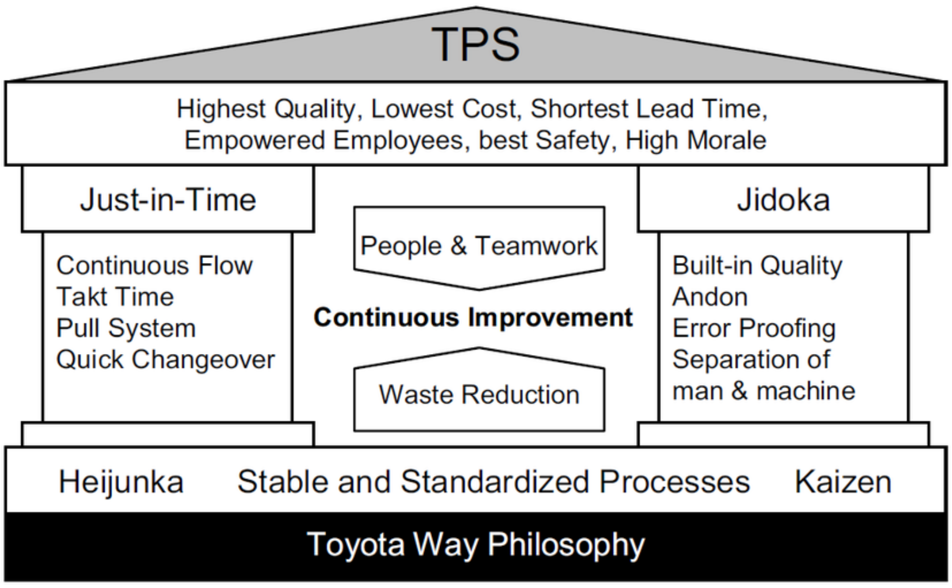

Fig 1: The core principle of the Toyota Production System (Herrmann et al, 2008)

However, the challenges Toyota faced during the Tohoku earthquake underscore the critical importance of vigorous project management techniques in the manufacturing sector (Liker & Convis, 2012). While Lean principles excel in optimizing routine operations by eliminating waste and streamlining processes, they alone may not suffice in addressing extraordinary disruptions. Project management techniques offer a comprehensive strategic framework that goes beyond day-to-day efficiency improvements (Kerzner, 2013). These techniques encompass detailed risk management practices that identify potential threats and vulnerabilities within the supply chain, allowing companies to develop proactive mitigation strategies (Project Management Institute, 2017). Furthermore, project management methodologies emphasize contingency planning, which prepares organizations for unforeseen events by establishing predefined action plans and resource allocations (Hillson & Simon, 2012). In the event of a disruption, such as the Tohoku earthquake, these plans facilitate a structured and swift response, minimizing downtime and mitigating impacts on production. Additionally, project management fosters enhanced coordination and communication across all levels of the organization, ensuring that critical information flows seamlessly and timely decisions are made (Kerzner, 2013). By integrating these techniques with Lean principles, manufacturing firms can achieve operational efficiency, resilience, and agility, enabling them to maintain stability and competitiveness even in the face of significant disruptions (Liker & Convis, 2012). Adopting Agile project management techniques could have improved Toyota's ability to adapt to the rapidly changing circumstances following the earthquake. Agile methodologies promote flexibility, iterative planning, and swift decision-making, allowing teams to pivot and implement alternative strategies as needed. This adaptability would have been crucial in minimizing downtime and resuming production more quickly (Schwaber & Sutherland, 2017).

The implementation of project management techniques in the manufacturing sector has become increasingly critical and important as industries strive to enhance efficiency, reduce costs, and improve product quality (Pozzi et al., 2023). Project management provides a structured framework that ensures systematic planning, execution, and control of production processes. Efficient implementation of these project management techniques helps meet deadlines and budget constraints and plays a vital role in risk management and resource optimization (Hindarto, 2023). Project management techniques, encompassing methodologies such as Lean Manufacturing, Six Sigma, Agile, and Critical Path Method (CPM), have demonstrated the potential to enhance efficiency and reduce production times (Stern, 2020).

1.2 Problem Statement

Over the years, the manufacturing sector has faced significant challenges in reducing production and processing times. Despite advancements in technology and management practices, many manufacturers continue to struggle with various obstacles and inefficiencies that unnecessarily prolong their production time, which in turn negatively affects their competitiveness and profitability (Koren, 2010). This inefficiency is partly a result of the underutilization of effective project management techniques that have proven successful in other industries, such as software development and services (Kerzner, 2013). For instance, the automotive industry, specifically in the United States, is under immense pressure to improve operational efficiency as a result of intense global competition and stringent regulatory requirements. These pressures are compounded by the cyclical nature of the industry, where peaks and troughs in demand often do not align with economic conditions (Womack et al., 2007). This misalignment results in substantial financial strain on manufacturers, necessitating a more agile and responsive approach to production management (Cusumano, 2010).

Traditional manufacturing strategies often focus on maximizing production capacity and meeting regulatory standards but fail to address the critical need for reducing lead times and enhancing overall productivity. As a result, manufacturers experience increased costs, longer time-to-market, and reduced ability to respond to market changes swiftly (Monden, 2011). The adoption of project management techniques tailored to the unique needs of the manufacturing sector presents a promising solution to these issues.

Project management techniques, such as Agile, Lean, and Six Sigma, have demonstrated success in other industries by enhancing process efficiency, improving quality, and reducing waste (George et al., 2005). However, their application in the manufacturing sector remains limited. Implementing these techniques can potentially streamline production processes, reduce bottlenecks, and optimize resource utilization, thereby significantly reducing production and processing times (Antony, 2006).

The problem, therefore, is the persistent inefficiency in production and processing times within the manufacturing sector, primarily due to the inadequate application of project management techniques. This inefficiency not only impacts the operational effectiveness of manufacturers but also their competitive edge in the global market (Flynn et al., 1995). There is a critical need for a comprehensive study to explore how project management techniques can be effectively adapted and applied to the manufacturing sector to address these inefficiencies (Kerzner, 2013).

This research aims to fill the gap by investigating the potential of project management techniques in reducing production and processing times in the manufacturing industry. By identifying best practices and developing a framework for their implementation, the study seeks to provide manufacturers with practical solutions to enhance their operational efficiency and competitiveness (Cusumano, 2010).

1.3 Study Purpose

The purpose of this study is to critically examine how the application of project management techniques can significantly reduce production and processing times in the manufacturing sector. Despite technological advancements and the adoption of various efficiency models, the manufacturing industry continues to grapple with persistent inefficiencies that impede optimal productivity. This study aims to identify the underlying causes of these inefficiencies and assess the potential of project management methodologies to address them effectively.

Manufacturing has historically been a cornerstone of economic development, yet it is plagued by challenges such as poor resource allocation, inadequate planning, and suboptimal execution strategies. These issues contribute to prolonged production cycles, increased operational costs, and reduced competitiveness on a global scale. Traditional efficiency models like Lean Manufacturing and Six Sigma have provided substantial improvements; however, they often fall short in the face of complex, unforeseen disruptions. The study will critically analyze these limitations and explore how project management techniques can fill the gaps left by these traditional models.

Project management techniques encompass a range of methodologies, including Agile, Critical Path Method (CPM), and Earned Value Management (EVM), each offering unique tools for improving planning, execution, and control of manufacturing processes. This study will evaluate the effectiveness of these techniques in streamlining operations, enhancing flexibility, and improving response times to disruptions. By critically analyzing case studies of manufacturing firms that have successfully implemented these techniques, the study will extract valuable insights and best practices that can be generalized across the industry.

Furthermore, the study will address the barriers to implementing project management techniques in the manufacturing sector. Resistance to change, cultural inertia, and the complexity of integrating new methodologies into existing systems are significant challenges that need to be overcome. By providing a critical examination of these barriers, the study aims to develop actionable recommendations for manufacturing firms seeking to enhance their operational efficiency through project management.

Lastly, the study will assess the long-term sustainability of efficiency improvements achieved through project management techniques. It will explore whether these improvements can be maintained over time and how they impact the overall resilience and adaptability of manufacturing operations in the face of future challenges. By taking a comprehensive and critical approach, this study intends to contribute valuable knowledge to the field of manufacturing and provide a strategic framework for companies aiming to reduce production and processing times through the effective application of project management techniques.

1.4 Study Aim, Research Objectives and Research Questions

This study aims to investigate the application of project management techniques to reduce production and processing times in the manufacturing sector, thereby enhancing overall efficiency and competitiveness. Hence the objectives of the study are;

1.3.1 Research Objectives

i. Identify common production inefficiencies in the manufacturing sector;
ii. assess the Impact of Project Management Techniques on Production Cycle Time in the Manufacturing Sector;
iii. assess the long-term sustainability of efficiency improvements achieved through project management techniques
iv. Develop Context-Specific Recommendations for the Application of Project Management Techniques in Various Manufacturing Environments;

1.3.2 Research Questions

i. What are the common production inefficiencies in the manufacturing industry
ii. How do various project management techniques, such as Lean, Six Sigma, and Agile, influence the production cycle time in manufacturing operations?
iii. How sustainable are the efficiency improvements achieved through project management techniques over the long term in manufacturing operations?
iv. How sustainable are the efficiency improvements achieved through the application of project management techniques in the long term?
v. What are the best practices and customization strategies for applying project management techniques in different types of manufacturing operations?

CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction

The manufacturing sector is a critical driver of economic growth, innovation, and employment globally. However, it faces persistent challenges related to inefficiencies in production and processing times. These inefficiencies can result in increased costs, reduced competitiveness, and lower profitability. The application of project management techniques offers a promising avenue to address these challenges by providing structured approaches to planning, execution, and control. This chapter reviews the existing literature on production inefficiencies in the manufacturing sector and the effectiveness of various project management methodologies in mitigating these inefficiencies. It explores foundational theories and models, including Lean Manufacturing, Six Sigma, Agile, and Critical Path Method (CPM), and assesses their impact on reducing production times. Additionally, the review examines case studies of manufacturing firms that have successfully implemented these techniques, highlighting best practices and common pitfalls. By synthesizing current research, this chapter aims to provide a comprehensive understanding of how project management techniques can enhance efficiency and productivity in manufacturing. The insights gained from this literature review will form the basis for developing a framework to guide the effective application of project management techniques in the manufacturing sector.

2.2 Production Inefficiencies in The Manufacturing Sector

The manufacturing sector, while being a pivotal contributor to global economic growth, faces significant inefficiencies that impede optimal performance. This section critically reviews the literature on production inefficiencies in the manufacturing sector, examining various dimensions such as resource allocation, process optimization, and the integration of advanced methodologies. It highlights the critical gaps and proposes potential areas for future research.

Effective resource allocation is fundamental to manufacturing efficiency, yet numerous studies highlight persistent challenges in this area. According to Khan et al. (2022), misallocation of resources often leads to bottlenecks, underutilization of capacity, and increased operational costs. For instance, the over-reliance on manual processes without adequate investment in automation technologies is a recurrent issue (Khan et al., 2022). This is prevalent in small-scale manufacturing firms, as they often struggle with high labor costs and low productivity due to their dependence on manual labor. This reliance leads to increased error rates, inconsistent product quality, and inefficiencies that hinder scalability and competitiveness in the global market. Consequently, these firms face significant operational challenges that could be mitigated through strategic investments in automation technologies (Kusiak, 2018). Without such investments, they remain at a disadvantage compared to automated counterparts. Furthermore, inadequate training and development of the workforce can result in suboptimal use of advanced machinery and technologies, exacerbating inefficiencies (Kumar & Parashar, 2015).

The optimization of manufacturing processes is crucial for reducing production times and costs. Lean Manufacturing and Six Sigma are widely adopted methodologies aimed at process improvement. However, Herrmann et al. (2008) argue that while Lean principles are effective in waste reduction, they often fail to address variability and complexity in production processes. Similarly, Six Sigma focuses on reducing defects but may not be flexible enough to adapt to rapid market changes (Antony, 2004). These methodologies require substantial cultural and organizational changes, which are often met with resistance, further complicating their effective implementation (Henderson & Evans, 2000).

The integration of advanced technologies such as IoT, AI, and robotics holds promise for addressing inefficiencies. However, the transition from traditional manufacturing systems to smart manufacturing is fraught with challenges. According to Pozzi et al. (2023), the high cost of technology adoption, coupled with a lack of skilled personnel, hampers the widespread implementation of these innovations. Additionally, the literature points to the issue of interoperability between new technologies and existing systems, which can lead to significant downtime and increased complexity in managing production processes (Kusiak, 2018).

Real-world applications and case studies provide valuable insights into the practical challenges of reducing production inefficiencies. Toyota's Lean manufacturing system, despite its successes, faced significant setbacks during the 2011 Tohoku earthquake, which revealed vulnerabilities in its just-in-time inventory approach (Norio et al., 2013). This case underscores the need for robust risk management and contingency planning, which are often overlooked in efficiency-driven methodologies. Similarly, studies on other manufacturing firms highlight the importance of balancing efficiency with resilience to external shocks (Schemel, 2021).

Various literatures consistently identify several barriers to the effective implementation of efficiency-enhancing methodologies. Resistance to change is one of the major obstacle, often rooted in organizational culture and lack of management support (Achieng, 2021). Additionally, the complexity of integrating new processes and technologies into existing workflows can lead to significant disruptions and reduced productivity in the short term (Hindarto, 2023). Overcoming these barriers requires a holistic approach that includes strategic planning, stakeholder engagement, and continuous training and development.

2.1 Lean Manufacturing

Lean Manufacturing, a methodology originating from the Toyota Production System (TPS), has gained significant traction in the manufacturing industry as a means to enhance operational efficiency and eliminate waste (Pawlik et al., 2021). The core principle of Lean Manufacturing revolves around the continuous improvement process, waste reduction, quality enhancement, and the creation of value for customers by streamlining manufacturing processes (Bashar & Hasin, 2019). By focusing on eliminating non-value-added activities and optimizing production processes, Lean Manufacturing aims to enhance productivity, reduce costs, and improve overall performance (Kumar et al., 2022). According to Leksic et al., (2020), Lean Manufacturing focuses on waste elimination and process optimization, directly impacting production timelines. By advocating for continuous improvement and the elimination of non-value-added activities, lean principles can significantly reduce cycle times and improve throughput.

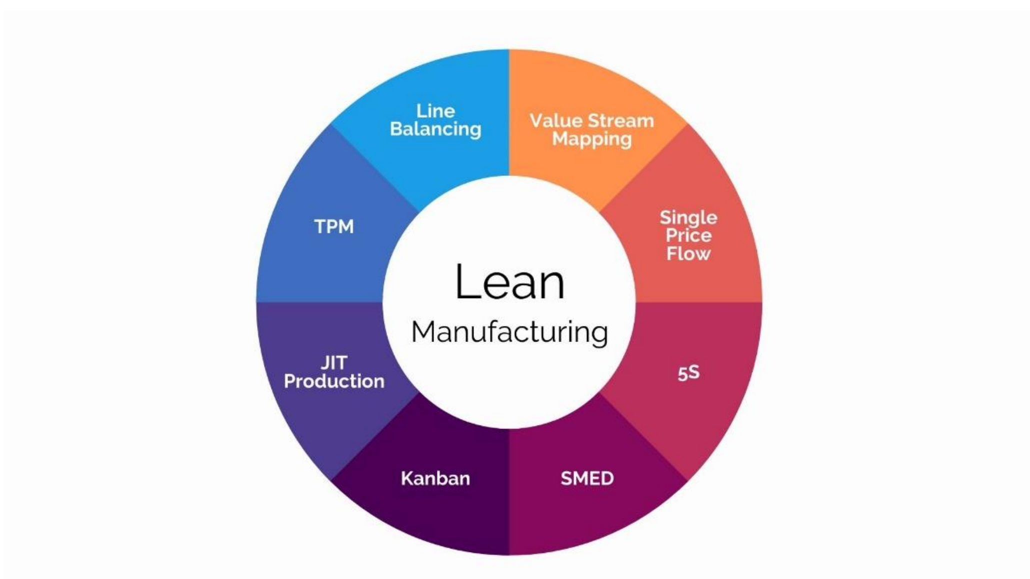

Fig 2: Lean Manufacturing

Techniques such as value stream mapping would be very important in identifying inefficiencies, while tools like 5S and Kanban would significantly streamline workflow and inventory management, leading to a significant cut in production time (Wang et al., 2024). Lean manufacturing also emphasizes employee involvement and systematic problem-solving to enhance productivity and quality (Harnandez-Matias et al., 2020). This holistic approach not only shortens production cycles but also increases overall operational efficiency, leading to cost savings and greater customer satisfaction. Implementing lean strategies allows manufacturers to respond more agilely to market demands and technological advancements, fostering a culture of constant enhancement (Javaid et al., 2022).

Numerous studies have highlighted the benefits of implementing Lean Manufacturing practices across various industries. Research has shown that Lean Manufacturing facilitates quality improvement, productivity enhancement, and cost reduction in companies that adopt its principles (Khalfallah & Lakhal, 2020). Additionally, the integration of Lean Manufacturing with other methodologies such as Agile Manufacturing has been found to further enhance operational and financial performance (Romero et al., 2019). This integration underscores the interconnectedness of different manufacturing practices and the potential synergies that can be achieved by combining them effectively. One of the key aspects of Lean Manufacturing is the identification and elimination of waste throughout the production process. This systematic approach to waste reduction is essential for creating value efficiently and meeting customer demands (Ramadas & Satish, 2021). Lean Manufacturing emphasizes the importance of continuous improvement and the removal of inefficiencies to optimize production systems (Romero et al., 2019). By focusing on activities that add value and minimizing those that do not, companies can enhance their competitiveness and sustainability in the market (Elnadi & Shehab, 2021).

Moreover, Lean Manufacturing is not limited to the shop floor but extends to various industries beyond traditional manufacturing sectors. From primary metals to aerospace businesses, the principles of Lean Manufacturing have been successfully applied to improve operational efficiency and drive performance excellence (Hines et al., 2004). This broad applicability underscores the versatility and effectiveness of Lean Manufacturing as a methodology for achieving operational excellence in diverse organizational settings.

In the context of small and medium-scale enterprises (SMEs), the implementation of Lean Manufacturing may face challenges related to employee barriers and resistance to change. Understanding and addressing these barriers are crucial for successful Lean Manufacturing adoption within SMEs (Ramadas & Satish, 2018). Creating a Lean culture within organizations is essential for the successful implementation of Lean Manufacturing practices and ensuring sustained improvements in operational performance (Aripin et al., 2023). By fostering a culture of continuous improvement and employee engagement, companies can overcome obstacles and drive successful Lean Manufacturing initiatives. Furthermore, Lean Manufacturing is not a static concept but continues to evolve in response to changing industry landscapes and technological advancements. The integration of Lean Manufacturing with emerging technologies such as Industry 4.0 and cyber-physical systems presents new opportunities for waste identification and elimination in the digital manufacturing world (Romero et al., 2019). By leveraging these technologies, companies can enhance their Lean Manufacturing practices and achieve greater efficiency in production processes.

2.3 Agile Project Management

Agile project management is a methodology that emphasizes flexibility and adaptability in project execution by promoting increased collaboration and communication among project stakeholders (Zasa et al., 2021). This approach aims to prevent large-scale project failures by enabling iterative development processes that allow for continuous feedback and adjustments throughout the project lifecycle (Mergel et al., 2021). By breaking down complex projects into smaller, manageable tasks, Agile project management facilitates the delivery of incremental value to stakeholders through rapid iterations (Ebirim *et al.*, 2024).

Agile methodologies facilitate adaptive planning and continuous improvement, which are essential for effectively responding to the ever-changing market demands and technological advancements. The iterative approach inherent in Agile allows manufacturers to quickly pivot and make necessary adjustments in real-time, reducing downtime and enhancing overall efficiency. This adaptability is particularly beneficial in a manufacturing environment where delays and inefficiencies can significantly impact productivity and costs. According to Amajuoyi et al., (2024), by breaking down projects into smaller, manageable increments, Agile enables frequent reassessment and optimization of processes, fostering a culture of constant improvement. This continuous feedback loop not only accelerates the production cycle but also improves product quality, ensuring that manufacturers can meet customer demands more swiftly and effectively. Thus, the integration of Agile methodologies into manufacturing operations represents a strategic advantage in maintaining competitiveness and operational excellence (Varl et al., 2020).

One of the key aspects of Agile project management is its ability to foster creativity within project teams. Research has shown that Agile methodologies provide conducive environments for creativity by promoting collaboration, flexibility, and a focus on delivering value to customers (Olszewski, 2023). Additionally, Agile project management has been found to drive innovation in various industries, such as energy-efficient HVAC solutions, by prioritizing iterative development and quick response to changing requirements (Ebirim *et al.*, 2024). While Agile project management offers numerous benefits, it also presents challenges, particularly in large enterprises where scaling Agile practices can lead to shifts in project management approaches and team dynamics (Sońta-Drączkowska, 2024). The role of the project manager in Agile software teams has been a subject of study, with research aiming to clarify ambiguities and questions surrounding the responsibilities and contributions of project managers in Agile environments (Gandomani et al., 2020). It is essential for project managers to adapt to the Agile methodology, which requires a different set of skills and approaches compared to traditional project management practices.

Risk management is another critical aspect of Agile project management. While Agile methods are known for their flexibility and adaptability, they also introduce risks such as scope creep, timeline issues, and budget constraints (Elkhatib et al., 2022). Effective risk management in Agile projects involves identifying and addressing potential risks early on to ensure project success and customer satisfaction (Thom-Manuel, 2022). By integrating risk management practices into Agile software development projects, teams can mitigate uncertainties and improve project outcomes. The transition from traditional project management approaches to Agile methodologies requires careful consideration and planning. Organizations implementing Agile project management must focus on stakeholder engagement, collaboration, and flexibility to successfully adopt Agile practices (Pinto, 2023). Moreover, the integration of Agile methods with established project management frameworks like PMBOK can enhance project management practices by combining the strengths of both approaches (Silva, 2023).

In the context of project governance, middle managers play a crucial role in ensuring the success of Agile software development projects (Uwadi *et al.*, 2022). Their involvement in project governance activities helps maintain alignment with organizational goals, facilitate communication among team members, and address challenges that may arise during project execution. Additionally, Agile methodologies provide a framework for project management tasks that enable teams to be flexible, responsive to change, and deliver results iteratively (Miller, 2019). Overall, Agile project management has become increasingly popular across various industries due to its emphasis on collaboration, flexibility, and iterative development. By embracing Agile methodologies, organizations can enhance creativity, drive innovation, and improve project outcomes through effective risk management and stakeholder engagement. However, successful implementation of Agile project management requires a shift in mindset, adoption of new practices, and continuous improvement to adapt to changing project requirements and stakeholder needs.

2.3 Six Sigma

Six Sigma employs statistical tools to identify and eliminate defects, thereby streamlining processes and reducing time wastage (Duc & Thu, 2022). This project management technique focuses on process variability and aims for near-perfection, which leads to substantial improvements in production efficiency and quality. The methodology's core principles, Define, Measure, Analyze, Improve, and Control (DMAIC), systematically address inefficiencies and root causes of defects (Nandakumar et al., 2020). This structured approach ensures that variations are minimized, resulting in more consistent and predictable production outcomes. By reducing variability and defects, Six Sigma not only enhances product quality but also significantly shortens processing times. Implementing Six Sigma in manufacturing helps in achieving higher levels of customer satisfaction, cost savings, and competitive advantage (Madhani, 2020). The emphasis on data-driven decision-making and continuous improvement fosters a culture of excellence and operational efficiency, ultimately driving better business performance.

One key advantage of Six Sigma is its ability to utilize statistical tools to identify process issues accurately and demonstrate improvements using objective data (Feng & Manuel, 2008). This data-driven approach is crucial in healthcare, where precision and quality are paramount. Moreover, the literature review by Utomo (2020) focuses on the implementation of Six Sigma in service industries, offering insights into how this methodology can be applied beyond manufacturing sectors. This broadening of Six Sigma's scope to service industries, including healthcare, highlights its versatility and effectiveness in diverse settings. The study specifically addresses the use of Six Sigma to reduce errors in healthcare payer firms, showcasing its potential in addressing specific challenges within the healthcare sector (M & Kunnath, 2019).

Various studies have highlighted the successful application of Six Sigma in different manufacturing sectors such as ceramic, paper, gems and jewellery, cement, furniture, and forging industries (Patel & Desai, 2018). The methodology has been utilized to address specific issues like reducing failure rates in high voltage testing of insulators (Desai & Shaikh, 2018), improving grinding processes (Noori & Latifi, 2018), and preventing industrial accidents (Ray et al., 2011). Additionally, Six Sigma has been instrumental in reducing oil leakage in heavy-duty transformers Neeru et al. (2023) and enhancing the effectiveness of training and development in the pharmaceutical industry (Chakraborty and Pant, 2024). Lean Six Sigma, a combination of Lean Manufacturing and Six Sigma, has also gained prominence in the manufacturing sector for driving sustainable practices and improving environmental performance (Huang et al., 2023). Studies have shown that Lean Six Sigma principles, data-driven decision-making, and a positive company culture contribute to enhancing sustainability while maintaining competitiveness (Huang et al., 2023). Furthermore, the integration of Lean Manufacturing and Six Sigma has been effective in continuous improvement initiatives in industries and services (Silva, Oliveira and Magalhães, 2023).

The success factors for implementing Six Sigma in the manufacturing industry have been identified as leadership and strategy, focus on market and customer, evaluation and motivation, and project management (Yi-zhong *et al.*, 2008). These critical success factors play a significant role in the effective implementation of Six Sigma methodologies in manufacturing enterprises. Moreover, the application of Six Sigma has been associated with reducing defects, increasing sigma levels, and improving overall performance in industries like the pharmaceutical sector (Alkunsol *et al.*, 2019).

2.4 Critical Path Method (CPM)

The Critical Path Method (CPM) provides a structured approach to project scheduling, identifying the longest sequence of tasks that must be completed on time for the entire project to be finished on schedule (Suryono & Hasbullah, 2020). By focusing on critical tasks and managing dependencies effectively, CPM helps minimise delays and optimise resource utilization (Taghipour et al., 2020). This method ensures that resources are allocated efficiently to critical tasks, preventing bottlenecks and reducing production cycle times. By clearly outlining task sequences and timelines, CPM facilitates better coordination and communication among team members, leading to more streamlined operations (Khandekar, 2020). The emphasis on critical tasks ensures that any potential delays are promptly addressed, maintaining project momentum and ensuring timely project completion.

The Critical Path Method (CPM) is a widely recognized deterministic scheduling technique extensively used in various industries, particularly in project management and construction scheduling (Fadjar, Ali and Setiawan, 2023). CPM aids in identifying the critical path, which is crucial for determining the sequence of activities that dictate the minimum project duration (Pankaj, Kumar and Agarwal, 2020). By focusing on the critical path, project managers can streamline activities to accelerate project completion and mitigate delays (Ali, Tjendani and Witjaksana, 2024). CPM is instrumental in estimating project duration, assessing scheduling flexibility, and optimizing project timelines (Wulandari, Dachyar and Farizal, 2018). It is a fundamental tool for project planning, controlling, and monitoring, ensuring efficient resource utilization and workflow management (Olivieri, Seppänen and Denis Granja, 2018).

Moreover, CPM is often used in conjunction with the Project Evaluation and Review Technique (PERT) to enhance project success probability and identify critical tasks (Hana and Tjendani, 2022). The integration of CPM and PERT allows for a comprehensive analysis of project timelines and critical activities, aiding in effective project acceleration strategies (Hana and Tjendani, 2022). Additionally, CPM has been a cornerstone in construction project scheduling since its inception in the 1950s, highlighting its enduring relevance and effectiveness in time management and project scheduling (Ökmen, Bosch-Rekveldt and Bakker, 2022). While CPM is a robust scheduling method, criticisms have been raised regarding its deterministic nature, which overlooks uncertainties inherent in project schedules (Ock and Han, 2010). Despite this critique, CPM remains a prevalent and valuable tool in project management, offering a structured approach to project planning and control (Simion *et al.*, 2019).

2.5 Common production inefficiencies in the manufacturing sector

Common production inefficiencies in the manufacturing sector can stem from various challenges that the industry faces. These challenges include issues related to workforce education (Daum *et al.*, 2024), complexity in manufacturing systems (Huah, Mahmood and Rahman, 2018), managing product variety and customization (Andersen *et al.*, 2018), and the need for flexibility in production processes (Wan et al., 2021). Additionally, challenges such as inadequate process control and material handling in ultra-precision manufacturing (Adeleke, 2024), the limitations of traditional manufacturing technologies for large-scale production (Lee et al., 2020), and the low production rates of additive manufacturing compared to traditional processes contribute to inefficiencies (Coatanéa *et al.*, 2021).

Moreover, the industry grapples with challenges related to the adoption of new technologies like 3D printing (Shahrubudin et al., 2020), the need for continuous development of products and processes to meet customer expectations (Helman, 2022), and the impact of globalization on manufacturing environments (Ariafar et al., 2012). Furthermore, issues such as the high complexity in Engineer-To-Order operations (Strandhagen et al., 2019), regulatory challenges in the production of cell therapies (Hourd, 2014), and the barriers to digital transformation in manufacturing firms Ahmad et al. (2022) add to the inefficiencies faced by manufacturers.

To address these inefficiencies, manufacturers must focus on optimizing processes for cell therapy manufacturing (Fritsche et al., 2020), leveraging reinforcement learning for sustainable and lean production (Paraschos, 2024), and developing strategies for thriving in local manufacturing contexts (Koren et al., 2017). Additionally, the adoption of technologies like reconfigurable manufacturing systems, artificial intelligence-driven customized manufacturing factories, and digital twins for manufacturing processes support can enhance efficiency and address production challenges.

2.6 Project Management Techniques and Production Cycle Time in the Manufacturing Sector

Project management techniques play a crucial role in the manufacturing sector by influencing production cycle time. Effective project management can lead to streamlined processes, improved resource allocation, and enhanced coordination, ultimately reducing cycle times and increasing efficiency. Several key factors impact the production cycle time in manufacturing, and project management techniques can address these factors to optimize operations. One significant aspect influenced by project management techniques is the planning and scheduling of manufacturing processes. Proper project planning ensures that tasks are sequenced efficiently, resources are allocated effectively, and potential bottlenecks are identified and mitigated Irfan et al. (2021). By utilizing tools like the Work Breakdown Structure (WBS) matrix and techniques such as the Critical Path Method (CPM) and Project Evaluation Review Technique (PERT), project managers can break down complex projects into manageable tasks, set realistic timelines, and identify critical activities that directly impact cycle time (Sutrisna et al., 2018; Bagshaw, 2021).

Moreover, project management plays a vital role in resource management within manufacturing operations. Efficient allocation of resources, including materials, equipment, and manpower, is essential for optimizing production cycle times. Project managers can use advanced inventory management techniques, demand forecasting, and production planning processes to ensure that resources are utilized effectively and that production processes run smoothly (Yeshwanth & Bhavana, 2022; Dey, 2002). Additionally, talent management practices and transformational leadership can enhance employee performance and innovative work behavior, further contributing to improved production cycle times (Sayyam et al., 2020). Quality management practices also intersect with project management in the manufacturing sector. The implementation of quality practices not only ensures product quality but also impacts production efficiency. The adoption of Total Quality Management (TQM) principles can lead to continuous process improvement, waste reduction, and enhanced overall organizational performance (Zwikael & Globerson, 2007). By integrating quality management into project management processes, manufacturers can achieve higher levels of efficiency and reduce cycle times.

Furthermore, the application of digital transformation in project and capture management can drive sustainable growth in manufacturing SMEs by enabling real-time monitoring, data-driven decision-making, and improved collaboration among team members (Awonuga, 2024). The integration of big data analytics can further enhance project performance by providing valuable insights, predicting potential risks, and optimizing project outcomes (Mangla et al., 2020). In conclusion, project management techniques have a profound impact on production cycle times in the manufacturing sector. By leveraging tools and methodologies such as project planning, resource management, quality practices, and digital transformation, manufacturers can streamline operations, reduce inefficiencies, and ultimately improve production cycle times. Effective project management not only enhances operational efficiency but also contributes to overall business success and competitiveness in the dynamic manufacturing landscape.

2.7 Key Factors Influencing the Successful Implementation of Project Management Practices in Manufacturing

The successful implementation of project management practices in the manufacturing sector is influenced by various key factors that play a critical role in ensuring project success. These factors encompass a wide range of aspects, including leadership competencies, project planning and control, risk management, human factors, and external environmental considerations. By understanding and addressing these factors, manufacturing companies can enhance their project management capabilities and improve overall operational efficiency. One of the fundamental factors influencing the successful implementation of project management practices in manufacturing is the leadership competencies of project managers. Research has shown that inner confidence, self-belief, and effective leadership skills are essential for project managers to deliver projects successfully Geoghegan & Dulewicz (2008). Strong leadership can inspire teams, drive project progress, and navigate challenges effectively, ultimately contributing to project success.

Effective project planning and control are also critical factors that impact the successful implementation of project management practices in manufacturing. Factors such as project-related considerations, project procedures, project management actions, and human-related factors all play a role in shaping the success of project planning and control processes (Li et al., 2018). By establishing clear project goals, defining project procedures, and implementing robust project management actions, manufacturing companies can enhance project planning and control efficiency. Moreover, the integration of risk management practices into project management processes can significantly influence project success in the manufacturing sector. Managing project risks, particularly in complex manufacturing projects such as the development of new car models, can lead to improved project management performance and overall project success (Fernando et al., 2018). By identifying and mitigating risks proactively, companies can minimize disruptions, optimize resource allocation, and enhance project outcomes.

Human-related factors, including effective communication, team coordination, and stakeholder engagement, also play a crucial role in the successful implementation of project management practices in manufacturing. Factors such as job satisfaction, competence of project team members, and effective communication channels are essential for fostering a collaborative and productive project environment (Kendra & Taplin, 2004). By prioritizing human factors and promoting a positive project culture, manufacturing companies can build strong project teams and drive project success. Additionally, external environmental considerations, such as market dynamics, regulatory requirements, and technological advancements, can influence the successful implementation of project management practices in manufacturing. Adapting to changes in the external environment, aligning project strategies with market demands, and leveraging technological innovations are essential for ensuring project success in a dynamic manufacturing landscape (Pacagnella et al., 2019). By staying attuned to external factors and proactively responding to market trends, companies can enhance their project management capabilities and drive successful project outcomes.

2.8 Long-term sustainability of efficiency improvements achieved through project management techniques

The long-term sustainability of efficiency improvements achieved through project management techniques in the manufacturing sector is crucial for ensuring continued success, competitiveness, and growth. By implementing effective project management practices and strategies, manufacturing companies can not only achieve short-term efficiency gains but also sustain these improvements over the long term. Several key factors contribute to the sustainability of efficiency improvements in manufacturing, including leadership commitment, continuous improvement culture, technology integration, and adaptability to changing market dynamics. Leadership commitment plays a pivotal role in sustaining efficiency improvements achieved through project management techniques. Strong leadership support and involvement are essential for driving organizational change, fostering a culture of continuous improvement, and ensuring that efficiency gains are maintained over time Fitriadi (2023). Leaders need to champion efficiency initiatives, allocate resources effectively, and provide guidance to project teams to sustain improvements and drive long-term success.

A culture of continuous improvement is another critical factor in ensuring the sustainability of efficiency improvements in manufacturing. By fostering a culture that values innovation, learning, and adaptability, companies can continuously identify opportunities for improvement, implement best practices, and optimize processes to enhance efficiency (Awonuga, 2024). Encouraging employee involvement, providing training on new methodologies, and recognizing and rewarding improvement efforts are essential for embedding a culture of continuous improvement within the organization. The integration of technology and digital transformation plays a significant role in sustaining efficiency improvements in manufacturing. Leveraging advanced technologies such as automation, data analytics, and artificial intelligence can help streamline processes, optimize resource utilization, and enhance decision-making capabilities (RONO, 2019). By embracing digital tools and platforms, manufacturing companies can drive operational efficiency, improve productivity, and adapt to changing market demands to sustain efficiency gains in the long run.

Furthermore, adaptability to changing market dynamics is crucial for sustaining efficiency improvements in manufacturing. The ability to respond to market trends, customer demands, and industry disruptions is essential for maintaining competitiveness and relevance in a dynamic business environment (Tito & Sarker, 2020). Manufacturing companies need to stay agile, monitor market changes, and adjust their strategies and operations to sustain efficiency improvements and meet evolving customer needs. Moreover, effective risk management practices are essential for ensuring the sustainability of efficiency improvements in manufacturing. By identifying potential risks, developing mitigation strategies, and monitoring performance metrics, companies can proactively address challenges and uncertainties that may impact efficiency gains (Chen & Yang, 2021). Robust risk management processes help safeguard against disruptions, ensure continuity of operations, and sustain efficiency improvements over the long term.

2.9 Project Management Techniques in Manufacturing: A Comparative Analysis of Their Impact on Production Efficiency

To understand the impact of project management techniques on production efficiency, a critical analysis of several empirical studies is essential. Each study provides unique insights, yet a comparative evaluation reveals commonalities and differences that can inform best practices and highlight research gaps. For instance, Aimee and Nkechi (2022) provide a comprehensive analysis of project management practices in the context of public construction projects in Rwanda. They emphasize the role of structured project management frameworks, such as the Project Management Body of Knowledge (PMBOK) and Agile methodologies, in enhancing project performance. Their findings indicate significant improvements in time management and resource allocation, suggesting that adopting formal project management practices can lead to more efficient project delivery. This study, however, primarily focuses on the public sector, leaving open questions about the direct applicability of these findings to the manufacturing industry.

Contrastingly, Ala et al. (2012) developed a stochastic model aimed at optimizing production cycle times within the metal processing industry. Their approach highlights the critical role of statistical and probabilistic methods in identifying and mitigating delays in production processes. The model's success in reducing cycle times underscores the importance of data-driven decision-making and continuous process optimization, principles that are integral to both Lean and Six Sigma methodologies. Unlike Aimee and Nkechi's (2022) study, which focuses on broader project management practices, Ala et al. (2012) provide a more technical perspective, emphasizing the need for specific tools and techniques tailored to the manufacturing environment. Furthermore, Cuatrecasas-Arbós et al. (2015) focus on inventory management and manufacturing lead times. Their research demonstrates that effective monitoring and control mechanisms can significantly reduce production delays. By implementing Just-In-Time (JIT) and Kanban systems, manufacturers can streamline their operations, reduce excess inventory, and minimize lead times. This study's findings resonate with Lean manufacturing principles, which advocate for waste reduction and process efficiency. However, the study stops short of exploring the integration of these systems with other project management techniques, such as Agile or Six Sigma, which could potentially yield even greater efficiency gains.

Durakovic et al. (2018) extend the analysis to the implementation challenges and trends associated with Lean manufacturing. Their empirical research identifies common barriers to successful Lean implementation, such as resistance to change and lack of training. By addressing these challenges, organizations can better leverage Lean principles to enhance production efficiency. This study's critical insight is the recognition that technical solutions must be supported by cultural and organizational changes. This aligns with findings from Panayiotou, Stergiou, and Chronopoulos (2022), who implemented Lean Six Sigma toolsets and reported significant improvements in both production efficiency and quality control. Their case study highlights the synergistic effects of combining Lean and Six Sigma methodologies, providing a more holistic approach to process improvement.

On a similar note, Panayiotou, Stergiou, and Panagiotou (2022) emphasize the importance of low-cost, high-effect initiatives in small and medium-sized enterprises (SMEs). Their research suggests that SMEs can achieve substantial improvements by adopting Lean Six Sigma practices without the extensive resource investments typically associated with large-scale implementations. This is particularly relevant for SMEs in the manufacturing sector, where budget constraints often limit the scope of process improvement initiatives. The study advocates for a tailored approach that considers the unique challenges and opportunities within SMEs, thereby broadening the applicability of Lean Six Sigma.

Fernandez-Viagas and Framinan (2015) provide a nuanced perspective on the trade-offs between processing times and resource allocation. Their analysis of controllable processing times in project and production management reveals that optimal resource allocation can lead to significant reductions in processing times. This study's strength lies in its detailed examination of the relationship between resource inputs and time savings, offering valuable insights for manufacturers looking to balance efficiency with resource constraints. The findings complement those of Cuatrecasas-Arbós et al. (2015) by highlighting the importance of strategic resource management alongside process monitoring. However, while these studies provide valuable insights, there are notable inconsistencies and gaps. For instance, Aimee and Nkechi (2022) emphasize the broader benefits of structured project management frameworks, while Fernandez-Viagas and Framinan (2015) focus on the specifics of resource allocation and processing times. This discrepancy suggests a need for integrated research that combines the strategic perspectives of project management frameworks with the technical details of resource and process optimization.

Moreover, there is a lack of longitudinal studies examining the sustained impact of these methodologies over time. Most studies, such as those by Ala et al. (2012) and Panayiotou, Stergiou, and Chronopoulos (2022), provide short-term results without addressing the long-term sustainability of the improvements achieved. Longitudinal research could provide deeper insights into the durability of these efficiency gains and the factors that influence their persistence. Finally, while individual methodologies such as Lean, Six Sigma, and Agile have been studied extensively, there is limited research on their combined effects. Studies like those by Durakovic et al. (2018) and Panayiotou, Stergiou, and Panagiotou (2022) highlight the benefits of Lean Six Sigma, but there remains a gap in understanding how multiple methodologies can be integrated to maximize efficiency. This gap points to the potential for future research to explore hybrid approaches that leverage the strengths of various project management techniques.

Summary

The literature review highlights the critical inefficiencies prevalent in the manufacturing sector, with a particular focus on resource allocation, process optimization, and the adoption of advanced methodologies. Studies highlight persistent challenges such as resource misallocation, over-reliance on manual processes, and inadequate workforce training. The implementation of Lean Manufacturing and Six Sigma methodologies has shown significant promise in addressing these inefficiencies, though each has its limitations. Lean Manufacturing excels in waste reduction but struggles with variability, while Six Sigma's rigidity may not always adapt well to rapid market changes. The integration of advanced technologies like IoT, AI, and robotics presents significant potential for enhancing efficiency, though high adoption costs and interoperability issues remain barriers. Future research should focus on hybrid approaches that combine the strengths of different methodologies and investigate the long-term sustainability of efficiency improvements to provide a more comprehensive solution for the manufacturing sector's challenges.

CHAPTER THREE: RESEARCH METHODOLOGY

3.0 Introduction

The research methodology for this dissertation, titled "Reduction of Production/Processing Time in the Manufacturing Sector through the Application of Project Management Techniques," is designed to comprehensively address the research objectives and questions outlined. This study aims to explore how different project management techniques can effectively reduce production cycle times, identify key success factors for their implementation, evaluate the long-term sustainability of achieved efficiencies, and develop context-specific recommendations for various manufacturing environments. Hence this section discussed the research design, data collection, Sampling, Research Instruments, Data Analysis, and Ethical Considerations.

3.1 Research Design

The chosen research design for this dissertation is a mixed-methods approach, combining both quantitative and qualitative research methodologies. This method is particularly well-suited for this study as it allows for a more comprehensive and analysis of the research problem. By combining the strengths of both approaches, this design enables the triangulation of data, which enhances the validity and reliability of the research findings (Tashakkori & Teddlie, 2010). The qualitative data will provide depth and context to the quantitative findings, while the quantitative analysis will offer empirical support to the qualitative insights. This integrative approach ensures that the research findings are well-rounded, addressing both the 'how' and 'why' aspects of the research questions. This approach is particularly suitable as it allows for a comprehensive analysis of the impact of project management techniques on production and processing times in the manufacturing sector. By integrating quantitative and qualitative data, the mixed-methods approach provides a more complete understanding of research problems than either method alone (Creswell & Plano Clark, 2011).

3.1.1 Qualitative Research

The qualitative component of the research is designed to explore the deeper, contextual factors influencing the implementation and effectiveness of project management techniques. Qualitative research is particularly well-suited for understanding complex phenomena, such as organizational culture, leadership styles, and stakeholder engagement, which are critical in project management (Denzin & Lincoln, 2018). In this study, qualitative data will be gathered through semi-structured interviews with project managers, engineers, and other key stakeholders in the manufacturing sector. These interviews will allow for an in-depth exploration of the participants' experiences, challenges, and perceptions related to the adoption and execution of project management practices.

Thematic analysis will be employed to identify recurring patterns and themes within the qualitative data. This approach is justified by the need to uncover the underlying factors that contribute to or hinder the success of project management initiatives, as suggested by Braun and Clarke (2006). Additionally, case studies of specific manufacturing firms that have successfully implemented project management techniques will be conducted. Case studies are a powerful qualitative research tool, offering detailed insights into complex real-world issues within their natural context (Yin, 2018). These case studies will provide rich, contextualized examples of best practices and lessons learned, contributing to a more comprehensive understanding of the research problem.

3.1.2 Quantitative Research

Complementing the qualitative approach, the quantitative component of the research will involve the collection and analysis of numerical data to statistically evaluate the impact of project management techniques on production cycle times. Quantitative research is essential for establishing the extent of relationships between variables and for generalizing findings across larger populations (Creswell, 2014). In this study, quantitative data will be obtained through structured surveys distributed to project managers and operational heads in various manufacturing firms. These surveys will measure key variables such as the use of specific project management techniques, changes in production cycle times, and the perceived effectiveness of these techniques.

The data collected will be analyzed using statistical methods, including regression analysis and correlation analysis, to determine the strength and nature of the relationships between the implementation of project management techniques and the reduction in production times. The use of quantitative analysis is justified by the need to provide empirical evidence that supports or refutes the hypotheses generated from the literature review and qualitative findings (Field, 2017). Moreover, quantitative data will help to validate the qualitative perceptions, ensuring that the conclusions drawn are both strong and reliable.

3.1.3 Primary Research

Primary research forms the cornerstone of this study, enabling the collection of original data that is directly relevant to the research questions. The decision to conduct primary research is driven by the need to gather specific insights that are not readily available in existing literature, especially in the context of manufacturing operations. Through the collection of firsthand data, this research aims to bridge gaps identified in the literature review, offering a fresh perspective on the effectiveness and challenges of implementing project management techniques in manufacturing environments. According to Saunders, Lewis, and Thornhill (2019), primary research is crucial in exploratory studies where specific, context-dependent insights are required. By engaging with professionals in the field through surveys, interviews, and case studies, this research will capture nuanced information that secondary sources may not provide.

3.2 Data Collection

The choice of data collection instruments is critical to ensure that the research objectives are effectively addressed and that the data gathered is reliable and valid. In this study, a combination of interviews and questionnaires will be used to collect qualitative and quantitative data, providing a comprehensive understanding of how project management techniques influence production and processing times in the manufacturing sector.

3.2.1 Interviews

Type of Interview: The study will employ semi-structured interviews as the primary qualitative data collection instrument. Semi-structured interviews are particularly advantageous for this research as they allow for a balance between the flexibility of open-ended questions and the structure needed to ensure consistency across interviews (Bryman, 2016). This type of interview enables the researcher to explore specific themes in-depth while also allowing participants to express their views freely and introduce new perspectives that may not have been projected by the researcher.

Design of the Interview: The interview guide was carefully designed to cover key topics related to the research questions, such as the challenges and benefits of implementing project management techniques, the impact of these techniques on production cycle times, and the contextual factors that influence their success or failure. The interview guide includes open-ended and probing questions, allowing for in-depth exploration of the participants' experiences and perceptions. The use of open-ended questions is essential to gather rich qualitative data, as it encourages respondents to provide detailed responses based on the respondents' personal experiences (Kvale & Brinkmann, 2015).

Delivery of the Interview: The interviews will be conducted virtually via video conferencing platforms such as Zoom conference and Microsoft Teams, depending on the availability and preference of the participants. Video conferencing can provide flexibility and convenience, especially when participants are geographically dispersed (Opdenakker, 2006). As it is in this case where the interviewer is in the UK the interview will be done with respondents from manufacturing companies in Nigeria. All interviews will be recorded, with the participants' consent, to ensure accurate transcription and analysis of the data.

3.2.2 Questionnaires

Design of the Questionnaire: The questionnaire was designed to collect quantitative data that complements the qualitative insights gained from the interviews. It was structured to include closed and open-ended questions, providing a mix of quantifiable data and qualitative responses that add depth to the analysis. The closed-ended questions predominantly use a Likert scale format, where respondents will indicate their agreement level or disagreement with specific statements related to project management practices and their impact on production cycle times.

Likert Scale: The Likert scale is a widely used tool in survey research for measuring attitudes, perceptions, and behaviours, making it highly suitable for this study. A five-point Likert scale ranging from "Strongly Disagree" to "Strongly Agree" was used to assess participants' opinions on various aspects of project management techniques, such as their effectiveness, ease of implementation, and impact on efficiency. The use of a Likert scale enables the researcher to quantify subjective opinions, making it possible to perform statistical analyses on the responses (Joshi et al., 2015).

Layout of the Questionnaire: The questionnaire was carefully laid out to ensure clarity and ease of completion. It began with a brief introduction explaining the purpose of the study and assuring participants of the confidentiality of their responses. The questions were grouped into sections, each focusing on a specific aspect of the research, such as the type of project management techniques used, the perceived impact on production times, and the challenges encountered. Clear instructions was provided for each section, and the questions will be phrased in straightforward, unambiguous language to avoid confusion (Dillman, Smyth & Christian, 2014).

Delivery of the Questionnaire: The questionnaire was distributed electronically via email, WhatsApp, and other message means with a link to an online survey platform Google Forms. The use of an online platform allows for efficient data collection, as it enables the researcher to reach a larger sample and facilitates easy data management and analysis. Participants were given a set period to complete the questionnaire, and follow-up reminders was sent to encourage a high response rate. To increase engagement, the questionnaire was kept concise, with an estimated completion time of 10-15 minutes, ensuring that it is not overly burdensome for respondents.

3.3 Sampling

Quantitative Sample

To ensure statistical validity and generalisability of findings, this study aims for a sample size of at least 100 respondents from various manufacturing firms. This number balances the need for robust data with practical considerations of time and resource constraints. Stratified random sampling will be employed to ensure representation from different types of manufacturing sectors, such as automotive, electronics, and food processing. Stratified sampling is particularly effective in this context as it allows the researcher to ensure that subgroups within the population are adequately represented, thereby mitigating bias and enhancing the reliability of findings by including diverse perspectives (Etikan, Musa, & Alkassim, 2016).

Qualitative Sample

Approximately 5 semi-structured interviews with key stakeholders, including project managers and engineers, and detailed case studies will be conducted. This sample size is chosen to provide depth and richness of data, facilitating a comprehensive understanding of the implementation processes and challenges. Purposive sampling will be used for the qualitative component, allowing the selection of participants and case studies that are particularly knowledgeable about or experienced with the implementation of project management techniques. This method is justified as it focuses on information-rich cases that provide deep insights into the research questions (Palinkas et al., 2015).

3.4 Validity and Reliability

Ensuring the validity and reliability of the research instruments is crucial in producing credible and trustworthy results in any empirical study. Validity refers to the extent to which a research instrument measures what it is intended to measure, while reliability pertains to the consistency of the instrument in measuring the concept over time (Creswell & Creswell, 2018). For this dissertation, focused on reducing production/processing time in the manufacturing sector through project management techniques, both validity and reliability are paramount to producing meaningful and generalizable findings.

3.3.1 Validity

Different types of validity must be considered: content validity, construct validity, and external validity. Content validity ensures that the instrument fully represents the construct being studied. To achieve this, the interview questions and questionnaire items will be developed based on a comprehensive review of the literature on project management and production efficiency, ensuring that all relevant aspects of the concepts are covered (Hayashi et al., 2019). Subject matter experts in project management and manufacturing will be consulted to review the research instruments, providing feedback to refine the questions and ensure that they are both comprehensive and relevant to the study's objectives.

Construct validity is concerned with whether the instrument accurately measures the theoretical constructs it is intended to measure. In this research, construct validity will be established through the operationalization of key concepts, such as project management practices and production time efficiency, ensuring that the questions reflect the underlying theoretical frameworks. The use of established scales and measures from previous studies will also contribute to construct validity by aligning the instruments with proven research practices (Trochim & Donnelly, 2008).

External validity, or generalizability, relates to the extent to which the findings can be generalized beyond the study sample to other contexts. While this research focuses on a specific sector, the manufacturing industry, efforts will be made to ensure that the sample is representative of various sub-sectors within manufacturing. This will enhance the generalizability of the findings across different manufacturing environments (Leedy & Ormrod, 2019). Additionally, the mixed-methods approach, combining qualitative and quantitative data, will provide a more holistic understanding of the phenomena, increasing the likelihood that the findings are applicable in broader contexts.

3.3.2 Reliability

Reliability refers to the consistency and stability of the measurement process. A research instrument is considered reliable if it produces consistent results when repeated under similar conditions. In this study, several strategies will be employed to ensure the reliability of the data collection instruments. **Test-retest reliability** will be assessed by administering the same questionnaire to a pilot group at two different points in time and then correlating the scores to measure stability over time (Bryman, 2016). If the correlation is high, the instrument can be deemed reliable in capturing consistent data.

Inter-rater reliability will be particularly important for the qualitative data collected through interviews. This will be addressed by having multiple researchers independently code a sample of the interview data and then comparing the consistency of their coding. Any discrepancies will be discussed and resolved to ensure that the coding process is reliable across different raters (Cohen et al., 2018). This step is essential to reduce subjective bias and ensure that the qualitative analysis accurately reflects the participants' responses.

Internal consistency reliability, which refers to the degree to which items within a questionnaire are consistent in measuring the same construct, will be measured using Cronbach's alpha. A Cronbach's alpha coefficient of 0.7 or above will be considered acceptable, indicating that the items in the scale are reliably measuring the same underlying concept (Field, 2018). This statistical measure will be applied to the Likert scale items in the questionnaire to ensure that the different items contribute consistently to the overall construct.

Data Analysis

Quantitative Analysis

Quantitative data collected through questionnaires will be analysed using statistical methods such as regression analysis, ANOVA (Analysis of Variance), and correlation analysis. Regression analysis will help identify the relationship between the use of specific project management techniques and the reduction in production cycle time. ANOVA will compare the effectiveness of different project management techniques across multiple manufacturing firms. Additionally, correlation analysis will examine the strength and direction of relationships between variables, such as the extent of project management implementation and the degree of time reduction achieved. The use of statistical methods such as regression analysis, ANOVA, and correlation analysis is essential for identifying relationships and comparing the effectiveness of different project management techniques in reducing production cycle time. Descriptive statistics summarise the data and highlight patterns or anomalies, while reliability and validity checks ensure the robustness of the questionnaire data (Mertler & Vannatta, 2017; Tavakol & Dennick, 2011).

Descriptive statistics will be employed to summarise the survey data. Measures such as mean, median, mode, standard deviation, and frequency distributions will provide an overview of the prevalence and effectiveness of different project management practices within the sample population. These descriptive statistics are crucial for presenting the data in a comprehensible manner and for identifying patterns or anomalies that warrant further investigation (Mertler & Vannatta, 2017).

Ensuring the reliability and validity of the questionnaire data is vital. Cronbach's alpha will be used to assess the internal consistency of the questionnaire items, ensuring that they reliably measure the intended constructs (Tavakol & Dennick, 2011). Construct validity will be evaluated through factor analysis, ensuring that the questionnaire accurately captures the dimensions of project management practices and their impact on production time.

Qualitative Analysis

Qualitative data from interviews will be analysed using thematic analysis, a method for identifying, analysing, and reporting patterns (themes) within data (Braun & Clarke, 2006). This approach involves coding the data, searching for themes, reviewing themes, defining and naming themes, and producing the report. Thematic analysis will help uncover the critical success factors, barriers, and context-specific adaptations related to the implementation of project management techniques. Thematic and content analyses are chosen for qualitative data to systematically uncover patterns, success factors, and barriers related to project management implementation. These methods complement the quantitative analysis, providing a comprehensive understanding of the research problem (Braun & Clarke, 2006; Krippendorff, 2018).

Additionally, content analysis will systematically categorise qualitative data to draw meaningful inferences. This method involves coding the data into predefined categories, which helps manage large volumes of qualitative information and facilitates the identification of trends and patterns (Krippendorff, 2018). By triangulating the findings from content analysis with quantitative results, the study ensures a comprehensive understanding of the research problem.

Ethical Considerations

Ethical considerations such as informed consent, confidentiality, and ethical approval are crucial to protect participants' rights, ensure privacy, and maintain research integrity. These measures align with ethical standards and legal requirements, promoting trust and compliance (Wiles, 2012; Babbie, 2016; Resnik, 2018).

Informed Consent

Obtaining informed consent from all participants is a fundamental ethical requirement. Participants must be fully informed about the nature, purpose, and potential risks of the study before they agree to participate. This includes providing clear information about how their data will be used and ensuring they understand that participation is voluntary (Wiles, 2012). Informed consent ensures respect for participants' autonomy and protects their rights.

Confidentiality

Maintaining the confidentiality of participants is crucial to protect their privacy and build trust. Personal identifiers will be removed from the data, and anonymised codes will be used during analysis. Data will be securely stored, and only authorised personnel will have access to it. This ensures compliance with ethical standards and data protection regulations (Babbie, 2016).

Ethical Approval

Before commencing data collection, ethical approval will be sought from the relevant institutional review board (IRB). The IRB will review the research proposal to ensure that it complies with ethical guidelines and that potential risks to participants are minimised. Ethical approval is necessary to safeguard the welfare of participants and maintain the integrity of the research process (Resnik, 2018).

Summary

The chosen sampling methods and research instruments are designed to comprehensively address the research objectives and questions. Stratified random sampling and purposive sampling ensure representative and information-rich samples, respectively. The questionnaire, as the primary quantitative instrument, offers efficiency, standardisation, and broad reach, while the semi-structured interview guide and case study protocol provide depth and contextual understanding. Together, these methods and instruments form a robust framework for investigating the impact of project management techniques on production and processing times in the manufacturing sector.

CHAPTER FOUR: DATA ANALYSIS, PRESENTATIONS AND DISCUSSION OF FINDINGS

4.1 Introduction

This chapter provides a comprehensive analysis of data gathered from questionnaires and interviews, focusing on multiple research objectives related to the use of project management techniques and how these techniques help in reducing time in manufacturing. The chapter includes both quantitative analysis which was done through descriptive and regression analysis and thematic analyses. It covers the assessment of cycle time reduction, factors contributing to reduced production time, sustainability of efficiency improvements, and the determination of best practices and customization strategies. The analyses were conducted through descriptive statistics, regression analysis, and thematic coding, offering understandings into the effectiveness, adaptation, and challenges of applying project management techniques in manufacturing operations.

4.2 Presentation of findings

Table 4.1: Demographic Analysis

Demographic Category	Subcategory	Frequency	Percentage
Job Title	Project Manager	28	29.79%
	Operations Manager	18	19.15%
	Engineer	22	23.40%
	Factory Worker	26	27.66%
Years in Manufacturing	Less than 1 year	15	15.96%
	1-3 years	21	22.34%
	4-6 years	19	20.21%
	7-10 years	17	18.09%
	More than 10 years	22	23.40%
Type of Manufacturing	Toiletries	17	18.09%
	Soap	22	23.40%
	Food Processing	24	25.53%
	Metal Processing	16	17.02%
	Plastics	15	15.96%

The analysis of questionnaire data reveals a diverse distribution of job titles within the manufacturing sector, underscoring the critical roles necessary for effective operations. Project Managers, comprising 29.79% of respondents, are pivotal in aligning production goals with organisational objectives, emphasising the necessity of structured oversight to enhance productivity and reduce costs (PMI, 2021). Similarly, the significant presence of Factory Workers (27.66%) highlights their central role in transforming managerial plans into tangible outputs, underscoring the sector's reliance on skilled labour for operational efficiency. Engineers, representing 23.40% of respondents, drive innovation and process optimisation, essential for maintaining global competitiveness (Kerzner, 2017). Operations Managers (19.15%) further ensure that production processes are streamlined, reducing waste and improving efficiency (Crawford, 2019). The varied experience levels among respondents—ranging from newcomers to seasoned professionals—foster both innovation and operational stability. This blend of fresh perspectives and deep expertise is critical for swiftly adapting to technological advancements and market changes, which is key for reducing production and processing times (Harrison & Lock, 2017; Nonaka & Takeuchi, 1995).

4.3 Analysis of Questionnaire

This section shows the results from the analysis based on the research questions which were then analysed descriptively.

4.3.1 Project Management Techniques

Table 4.2: Frequency of Using Project Management Technique

Question	Always	Often	Sometimes	Rarely	Never	Mean
How often does your company use project management techniques?	28 (29.8%)	21 (22.3%)	19 (20.2%)	16 (17.0%)	10 (10.6%)	2.47

Table 4.2 provides insights into the extent to which project management techniques are employed within the sampled firms. The mean score of 2.47 suggests a moderate application of these techniques,

with 29.8% of respondents indicating they "Always" use these methods and 22.3% stating they use them "Often." However, 27.6% of respondents reported "Rarely" or "Never" employing these techniques, raising concerns about the thoroughness of project management practices. This variability in usage may stem from differences in project types, management approaches, or the lack of necessary skills and capacities (Turner, 2016).

Table 4.3: primarily used project management methodologies

Question	PRINCE2	Waterfall	Agile	Lean Six Sigma	PMBOK (Project Management Body of Knowledge)	Mean
Which project management methodologies are primarily used in your company?	60 (63.8%)	50 (53.2%)	55 (58.5%)	66 (70.2%)	43 (45.7%)	2.91

Table 4.3 reveals that Lean Six Sigma is the most commonly used methodology, with 70.2% of respondents indicating its adoption, reflecting its emphasis on waste reduction and process efficiency in manufacturing (Antony, 2018). PRINCE2 (63.8%) and Agile (58.5%) are also widely employed, suggesting a trend towards integrating multiple methodologies to meet diverse project requirements. The relatively lower use of PMBOK (45.7%) may indicate a preference for methodologies that directly address specific manufacturing challenges, given that PMBOK is often seen more as a guiding framework than a practical approach (Kerzner, 2017).

Table 4.4: effectiveness of project management techniques

Question	Very Effective	Effective	Neutral	Ineffective	Very Ineffective	Mean
Rate the effectiveness of project management techniques in improving production processes in your company.	23 (24.5%)	25 (26.6%)	18 (19.1%)	14 (14.9%)	14 (14.9%)	2.79

Table 4.4 assesses the perceived effectiveness of project management techniques in enhancing production processes. While 26.6% of respondents found these techniques "Effective" and 24.5% "Very Effective," a notable portion expressed neutrality or dissatisfaction, with 19.1% being "Neutral" and 29.8% finding them "Ineffective" or "Very Ineffective." This mixed perception may reflect issues related to implementation, skill levels, or resistance to change. Ahern, Leavy, and Byrne (2014) underscore that the success of these techniques hinges on the implementation context, project managers' expertise, and organisational culture, indicating areas for potential improvement.

4.3.2 Impact of Project Management Techniques on Production Cycle Time

Table 4.5: Reduction in Production Cycle Times

Question	Significantly reduced	Moderately reduced	Slightly reduced	No impact	Increased cycle times	Mean
To what extent have your company's project management techniques reduced production cycle times?	18 (19.1%)	22 (23.4%)	20 (21.3%)	20 (21.3%)	14 (14.9%)	2.88

The data in Table 4.5 reveals a diverse impact of project management techniques on production cycle times across the surveyed companies. Specifically, 19.1% of respondents reported a significant reduction in cycle times, while 23.4% observed a moderate reduction, yielding an average impact score of 2.88. This suggests that, on balance, project management techniques tend to moderately reduce cycle times. The notable success reported by some respondents may be due to the effective application of methodologies such as Lean and Six Sigma, which focus on eliminating waste and optimising processes (Antony, 2018). However, the findings also indicate that 21.3% of respondents experienced only a slight reduction, and another 21.3% saw no impact, highlighting that the effectiveness of these techniques can be highly context-dependent, with challenges such as resistance to change and inadequate training potentially limiting their success (Kerzner, 2017).

Table 4.6: Production Cycle Time Before Project Management Techniques

Question	2 - 5 days	6 - 10 days	11 - 15 days	16 – 20 days	Mean (days)
Production Cycle Time Before Project Management Techniques	0 (0%)	2 (2.04%)	41 (41.84%)	55 (56.12%)	15.05

Table 4.7: Production Cycle Time After Project Management Techniques

Question	2 - 4 days	5 - 7 days	8 - 10 days	Mean (days)
Production Cycle Time After Project Management Techniques	8 (8.33%)	50 (52.08%)	40 (39.58%)	7.84

Tables 4.6 and 4.7 further illustrate the effectiveness of project management techniques by comparing production cycle times before and after their implementation. Prior to the adoption of these techniques, the majority of respondents reported cycle times ranging from 16 to 20 days, with an average of 15.05 days. This indicates that pre-implementation processes were relatively inefficient, likely due to issues such as bottlenecks, poor resource allocation, and a lack of standardised procedures (Turner, 2016). Post-implementation, there was a marked improvement, with 52.08% of respondents now reporting cycle times between 5 and 7 days, and the mean cycle time significantly reduced to 7.84 days. This reduction underscores the effectiveness of project management techniques in streamlining processes and enhancing operational efficiency. The significant decrease in cycle time—from an average of 15.05 days to 7.84 days—demonstrates the transformative impact of structured project management

practices such as Agile and Lean, which facilitate quicker responses to changes and the elimination of non-value-adding activities (Joslin and Müller, 2015; Kerzner, 2017).

Table 4.8: Project management practices based on their impact on reducing production cycle times

Question	No Impact	Minimal Impact	Moderate Impact	Significant Impact	High Impact	Mean
Project Scheduling and Planning	10 (10.42%)	46 (47.92%)	26 (27.08%)	23 (23.96%)	24 (25.00%)	3.17
Risk Management	22 (22.92%)	26 (27.08%)	21 (21.88%)	24 (25.00%)	29 (30.21%)	3.18
Resource Allocation	15 (15.63%)	29 (30.21%)	27 (28.13%)	18 (18.75%)	30 (31.25%)	3.14
Quality Management	28 (29.17%)	25 (26.04%)	24 (25.00%)	23 (23.96%)	27 (28.13%)	3.22
Communication Management	22 (22.92%)	32 (33.33%)	24 (25.00%)	21 (21.88%)	28 (29.17%)	3.19

The questionnaire analysis provides critical insights into the perceived influence of various project management techniques on key operational areas within the manufacturing sector. These areas—Project Scheduling and Planning, Risk Management, Resource Allocation, Quality Management, and Communication Management—are integral to the effective execution of projects, and the responses reflect their varying levels of impact when these techniques are applied. The analysis of Project Scheduling and Planning reveals a mean score of 3.17, indicating a moderate to significant influence on production processes. Notably, while 25% of respondents acknowledged a high impact, 47.92% reported minimal influence. This disparity suggests challenges such as inadequate forecasting, inefficient use of scheduling tools, or resistance to structured planning methods (Kerzner, 2017). However, the significant impact reported by a quarter of respondents underscores the potential of effective scheduling and planning to enhance project efficiency (Turner, 2016).

Risk Management, with a mean score of 3.18, also shows a moderate to high impact. A significant 30.21% of respondents perceived a high impact of risk management practices, although 27.08% noted minimal impact. This variation highlights the varying degrees of integration of risk management strategies, with some organisations struggling to identify and mitigate risks effectively (Hillson, 2016). Tailoring these approaches to the manufacturing sector's specific needs is vital to mitigating disruptions that could affect production timelines and quality (Chapman and Ward, 2011). Similarly, Resource Allocation, scoring 3.14, indicates a moderate to significant impact, though 30.21% of respondents reported minimal influence. Effective resource allocation is crucial in manufacturing, where optimal use of materials, labour, and machinery directly impacts outcomes (Lock, 2013). The moderate impact observed may stem from challenges such as suboptimal resource distribution and lack of real-time tracking, while successful allocation can significantly improve project performance (Basu, 2017).

In terms of Quality Management, the analysis, with a mean score of 3.22, suggests a generally positive perception of its effectiveness. Approximately 28.13% of respondents noted a high impact, consistent with the importance of quality management practices such as Total Quality Management (TQM) or Lean

Six Sigma in maintaining production standards (Oakland, 2014). However, the presence of minimal or moderate impact responses may indicate challenges in continuous improvement initiatives or cultural resistance to quality-focused methodologies (Dale et al., 2016). Finally, Communication Management, with a mean score of 3.19, reflects a moderate to significant impact on project success. Despite 33.33% of respondents reporting minimal impact, the high impact acknowledged by others underscores the importance of effective communication in enhancing coordination and reducing misunderstandings in manufacturing projects (Pinto, 2013). The moderate impact observed may be due to inadequate communication channels and a lack of alignment between project objectives and execution (Maylor, 2010).

4.3.3 Factors Influencing Implementation

Table 4.9: Usage of Project Management Tools

Question	Never	Rarely	Sometimes	Often	Always	Mean
Usage of Project Management Tools	18 (18.75%)	26 (27.08%)	35 (36.46%)	37 (38.54%)	27 (28.13%)	3.28

The data in Table 4.9 demonstrates the varying frequency with which project management tools are utilised within respondents' organisations, with a mean score of 3.28. Notably, 38.54% of respondents reported frequent usage, while 28.13% indicated consistent, always-on use of these tools. Despite these positive indications, there is a significant portion of the workforce—27.08% who rarely and 18.75% who never utilise project management tools—highlighting a clear gap in consistent application across the board. This disparity may arise from factors such as a lack of familiarity with the tools, resistance to new technologies, or organisational constraints (Kerzner, 2017). Addressing these issues through enhanced training programmes and fostering a culture that values project management tools could improve their usage and thereby increase efficiency and project outcomes (Turner, 2016). Integrating these tools into daily operations and ensuring that employees are proficient in their use could further bridge this gap (Basu, 2017).

Table 4.10: Barriers to Implementing Project Management Techniques

Question	Lack of Skilled Personnel	Resistance to Change	High Implementation Costs	Inadequate Training	Lack of Management Support	Mean
Barriers to Implementing Project Management Techniques	47 (32.56%)	43 (29.86%)	61 (42.43%)	48 (33.33%)	32 (22.22%)	3.33

Table 4.10 provides insights into the barriers that organisations face when implementing project management techniques, with a mean score of 3.33 across identified challenges. High implementation costs, reported by 42.43% of respondents, emerge as the most significant barrier, a finding consistent with the literature, which often cites financial constraints as a critical challenge in adopting new project management methodologies, particularly in resource-limited environments (Hillson, 2016). Resistance to change, noted by 29.86% of respondents, further complicates the implementation process, likely driven by a lack of understanding of the benefits or fear of disruption (Pinto, 2013). Furthermore, the

lack of skilled personnel (32.56%) and inadequate training (33.33%) highlight the critical need for investment in human capital development to support effective implementation (Lock, 2013). Lastly, the lack of management support, although less frequently reported (22.22%), remains a crucial factor, as leadership plays a pivotal role in prioritising and sustaining project management initiatives (Chapman & Ward, 2011).

Table 4.11: Supportiveness of Management Towards Implementation

Question	Supportive	Neutral	Unsupportive	Very Unsupportive	Very Supportive	Mean
Supportiveness of Management Towards Implementation	45 (31.25%)	36 (25.00%)	31 (21.53%)	19 (13.19%)	26 (18.06%)	2.89

Table 4.11 explores the level of support that management provides towards the implementation of project management techniques, with a mean score of 2.89. The results reveal a concerning trend: 31.25% of respondents perceive management as supportive, but a significant portion (21.53% and 13.19%) views management as unsupportive or very unsupportive. This lack of perceived support can be detrimental to the successful implementation of project management practices, as it may lead to inadequate resource allocation, low employee morale, and ultimately, the failure of project initiatives (Kerzner, 2017). The data also shows that a quarter of the respondents (25%) remain neutral regarding management support, which may indicate uncertainty or variability in the level of support provided. This neutrality could be a sign that while management may not be overtly obstructive, they may not be actively championing project management initiatives either. Effective leadership is crucial for overcoming the barriers to implementation, as it provides direction, motivation, and a clear vision for the adoption of new practices (Oakland, 2014).

4.3.4 Sustainability of Improvements

Table 4.12: Sustainability of Improvements

Question	Sustainable	Neutral	Unsustainable	Very Unsustainable	Very Sustainable	Mean
Sustainability of Improvements	72 (50.00%)	42 (29.17%)	24 (16.67%)	20 (13.89%)	35 (24.31%)	3.3

Table 4.12 explores the respondents' perceptions regarding the sustainability of improvements derived from the application of project management techniques. With a mean score of 3.3, the findings reveal a generally optimistic view, as 50% of respondents categorized these improvements as "Sustainable," while 24.31% rated them as "Very Sustainable." This indicates a prevailing belief that the efficiency gains achieved through these techniques are likely to endure. However, a noteworthy portion of respondents (16.67% and 13.89%) expressed concerns, rating the improvements as "Unsustainable" or "Very Unsustainable," suggesting apprehension about the durability of these gains over time. Such concerns may stem from factors like evolving market conditions, technological advancements, and the dynamic nature of manufacturing processes, which can potentially undermine initially successful interventions (Kerzner, 2017). The mixed perceptions reflect the challenges highlighted in the literature regarding the

maintenance of improvements in complex and dynamic environments. Womack and Jones (2010) emphasise that sustaining improvements requires continuous commitment to process optimisation and proactive management of emerging challenges. Therefore, while the initial efficiency gains are commendable, their long-term sustainability demands ongoing adaptation and effort.

Table 4.13: Frequency of Reviewing and Updating Practices

Question	Monthly	Quarterly	Semi-annually	Annually	Never	Mean
Frequency of Reviewing and Updating Practices	33 (22.92%)	55 (38.19%)	38 (26.39%)	22 (15.28%)	22 (15.28%)	2.92

Table 4.13 offers insights into the frequency with which organisations review and update their practices to sustain improvements. The mean score of 2.92 indicates that reviews are conducted with varying regularity, with 38.19% of respondents noting quarterly reviews, while 26.39% report semi-annual reviews. Monthly reviews are less common, with 22.92% of respondents engaging in this practice, and 15.28% indicating annual or no reviews at all. The prominence of quarterly reviews suggests that many organisations are committed to regularly assessing and updating practices, aligning with best practices in continuous improvement. Regular reviews enable prompt responses to deviations and the implementation of corrective actions, ensuring sustained efficiency gains (Oakland, 2014; Basu, 2017). However, infrequent reviews pose risks to sustainability, as they may allow inefficiencies to re-emerge, eroding initial gains (Turner, 2016). This highlights the necessity of embedding a culture of continuous improvement within organisational routines, making regular reviews a consistent practice rather than an occasional activity.

4.4 Qualitative Analysis Thematic Analysis

4.4.1 Identify Common Production Inefficiencies in the Manufacturing Sector

For the study's first objective, which is to "Identify common production inefficiencies in the manufacturing sector," two questions were posed.

Identified Key Themes

Several key themes were identified based on provided response from the interviewee which is stated below:

1. **Inadequate Infrastructure and Equipment**
2. **Human Resource Challenges**
3. **Supply Chain Disruptions**
4. **Technological Limitations**

Theme 1: Inadequate Infrastructure and Equipment

One of the most dominant themes that emerged from the interviews was the inadequacy of infrastructure and equipment in the manufacturing firms. This theme was particularly highlighted by the Project Managers, who noted that outdated machinery and inconsistent power supply were significant barriers to maintaining production efficiency. Respondent A, a Project Manager, stated:

"You see, the problem is the equipment we are using is old, and this affects the speed of production. Sometimes, even the light no dey steady, so we have to stop production till the generator kicks in. This delay affects our target output for the day."

Similarly, Respondent B, another Project Manager, echoed this sentiment by highlighting the impact of equipment failure on production timelines:

"The machines we use, they break down often, and it's difficult to find the right parts here in Nigeria. When this happens, we have to wait for days, sometimes weeks, before we can get the necessary repairs done, and this hampers our productivity."

The issue of inadequate infrastructure and equipment was less emphasized by the Operations Managers, who seemed to focus more on the human resource aspects of production inefficiency. However, Respondent C did acknowledge that *"The frequent breakdown of machines na big wahala for us, but na the way we dey manage people wey dey operate them, that one na bigger issue."* This highlights a potential interaction between human resource management and the technical infrastructure within these firms, suggesting that inefficiencies may be compounded by a combination of factors.

Theme 2: Human Resource Challenges

The second prominent theme revolved around human resource challenges, particularly the lack of skilled labour and ineffective management practices. Respondent C, an Operations Manager, noted:

"One major issue we face is that the workers no get enough training. We dey hire people, but after some time, you realize say dem no really sabi how to operate the machines properly, and this leads to errors and delays."

This sentiment was echoed by Respondent D, another Operations Manager, who added that:

"Apart from the skill gap, there's also the issue of discipline. Sometimes, workers go come late or dem no go show up at all, and this disrupts the entire production process. We end up spending more time trying to get things back on track."

Interestingly, while the Operations Managers highlighted human resource challenges as a key source of inefficiency, the Project Managers were more likely to attribute these issues to a lack of adequate training and development programs. Respondent B stated:

"I believe if we invest more in training our workers, we will see a significant improvement in efficiency. But unfortunately, the company no too dey focus on that, and it's affecting our overall output."

This indicates a divergence in perspectives between Project Managers and Operations Managers regarding the root causes of human resource-related inefficiencies. The former seem to place more emphasis on the need for organizational investment in training, while the latter are more concerned with the day-to-day management of the workforce.

Theme 3: Supply Chain Disruptions

Supply chain disruptions emerged as another critical theme affecting production efficiency. Respondent A highlighted how delays in the supply of raw materials lead to production bottlenecks:

"Sometimes, we no fit get the raw materials on time because of transportation issues or customs delays. When this happens, everything just come to a halt. We dey wait for materials, and time dey go."

Respondent D also touched on this issue, noting that:

"The suppliers sometimes fail to deliver on schedule, and when that happens, we have to pause production. It's not something we have much control over, and it affects our ability to meet deadlines."

The respondents' comments indicate that supply chain disruptions are a significant external factor contributing to inefficiencies in the manufacturing process. However, it also highlights a lack of effective contingency planning within the firms to mitigate these disruptions. This aligns with findings from other studies that emphasize the importance of a robust supply chain management system in maintaining production efficiency (Ala et al., 2012; Fernandez-Viagas and Framinan, 2015).

Theme 4: Technological Limitations

Lastly, technological limitations were cited as a challenge, particularly in terms of integrating new technologies into existing manufacturing processes. Respondent C observed:

"Technology don improve, but we still dey struggle to integrate new systems. Sometimes, the new software no dey compatible with the old machines we dey use, and this leads to more issues."

Respondent B further commented on the slow pace of technological adoption in their firm:

"We dey talk about Industry 4.0, but the truth be say, we are far from reaching that level. The company no too dey ready to invest in the latest technology, and this puts us behind our competitors."

The responses suggest that while the potential for technological advancement exists, there is resistance or difficulty in adopting new technologies within these firms. This could be due to financial constraints, lack of technical expertise, or a reluctance to change established processes. The impact of technological limitations on production efficiency is well-documented in the literature, with several studies highlighting the need for continuous technological upgrades to maintain competitiveness in the manufacturing sector (Durakovic et al., 2018; Panayiotou et al., 2022).

4.4.2 Assess the Impact of Project Management Techniques on Production Cycle Time in the Manufacturing Sector

For the second objective, which aims to "assess the impact of project management techniques on production cycle time in the manufacturing sector," three questions were posed to the four respondents.

Key Themes Identified

Based on the responses provided by the interviewees, the following key themes were identified:

1. **Adoption of Lean and Six Sigma Techniques**
2. **Improvement in Production Cycle Time**
3. **Challenges in Implementing Project Management Techniques**
4. **Variability in the Perceived Impact**

Theme 1: Adoption of Lean and Six Sigma Techniques

A prevalent theme that emerged from the interviews was the adoption of Lean and Six Sigma techniques in the manufacturing processes of the soap-making companies. Respondent A, a Project Manager, mentioned:

"We mainly use Lean techniques to eliminate waste and improve efficiency. Six Sigma dey there too, but na Lean we dey focus on more because of the type of production we dey do."

Similarly, Respondent B highlighted that their company employs both Lean and Six Sigma, though Lean techniques were emphasized:

"Lean is very effective for our kind of business, where we dey produce large quantities of soap. Six Sigma dey help us to maintain quality, but Lean na the main one we dey use for reducing production cycle time."

Both Project Managers identified Lean as the primary technique, suggesting that its principles of waste reduction, streamlined processes, and continuous improvement align well with the needs of the soap manufacturing sector. Operations Managers also recognized the importance of these techniques, although they provided a broader perspective. Respondent C noted:

"We dey use Lean and Six Sigma, but sometimes, we also dey apply Agile principles, especially when we dey experiment with new soap formulations. This helps us to quickly adapt to changes and maintain our production schedules."

Respondent D similarly acknowledged the use of multiple project management techniques, adding that:

"Though Lean na the most common one, we dey try blend am with other methods depending on the situation. This flexibility helps us stay on track even when we face unexpected challenges."

The responses indicate that while Lean and Six Sigma are the dominant techniques used, there is also a degree of flexibility in adopting other methods, such as Agile, to address specific production challenges.

Theme 2: Improvement in Production Cycle Time

The impact of these project management techniques on production cycle time was another critical theme. All respondents agreed that implementing these techniques has led to improvements in their production processes, although the extent of these improvements varied. Respondent A provided a specific example:

"Before we introduced Lean, our production cycle time for a batch of soap was about 12 hours. Now, with Lean, we don reduce am to about 8 hours. We removed unnecessary steps and rearranged the workflow to make it more efficient."

Respondent B echoed this improvement but noted that while the overall cycle time has decreased, there are still areas for further refinement:

"We've seen a significant reduction in cycle time since adopting Lean and Six Sigma. For example, our packaging line used to be a major bottleneck, but with process re-engineering, we don reduce the time spent there by 30%. However, we still dey work on optimizing other parts of the production chain."

Operations Managers were also positive about the impact but highlighted that the improvements in cycle time depend on how consistently the techniques are applied. Respondent C remarked:

"Lean and Six Sigma have definitely helped us reduce cycle time, especially in the areas of material handling and assembly. But, the success of these techniques dey rely on how well the team fit follow the guidelines. Sometimes, we face setbacks when workers no follow the protocols strictly."

Respondent D added that the impact of these techniques is also influenced by external factors, such as supply chain issues:

"Our cycle time has improved with the use of these techniques, but we still face delays when materials no dey arrive on time. Even with the best techniques, you fit still encounter delays if other parts of the production process no dey in sync."

The respondents' comments suggest that while Lean and Six Sigma have effectively reduced production cycle time, the full benefits are contingent on consistent application and the alignment of all production-related processes.

Theme 3: Challenges in Implementing Project Management Techniques

A theme that was less emphasized but still significant was the challenge of implementing project management techniques effectively. Respondent A acknowledged that:

"Introducing Lean wasn't easy. We faced resistance from some workers who no gree change the way dem dey do things. It took time for them to understand the benefits, but eventually, they came around."

Respondent B also pointed out the challenge of maintaining the momentum after the initial implementation:

"The first few months after we introduced Lean, there was a lot of enthusiasm. But over time, it became harder to keep everyone motivated to follow the new procedures, especially when the results no show immediately."

Operations Managers shared similar concerns, with Respondent C noting that:

"One challenge we face is training. We dey try teach our workers how to apply these techniques, but not everyone dey grasp the concepts quickly. This can lead to inconsistent results and slower progress."

Respondent D further highlighted the difficulty of integrating these techniques into the existing company culture:

"Sometimes, the problem no be the techniques themselves, but how we dey integrate them into our way of working. Change is hard, and it takes time for everyone to adjust, especially when the company has been doing things a certain way for many years."

These challenges underscore the importance of proper training, communication, and cultural alignment when implementing project management techniques in manufacturing processes.

Theme 4: Variability in the Perceived Impact

The final theme that emerged was the variability in the perceived impact of these techniques on production cycle time. When asked to rate the impact on a scale of 1 to 5, the respondents provided varied ratings, reflecting different levels of satisfaction with the results. Respondent A rated the impact as a 4, explaining:

"I would say 4 because we've seen good results, but there's still room for improvement, especially in the areas where we face external challenges."

Respondent B also rated the impact as a 4, but for different reasons:

"I rate it a 4 because we've made significant progress, but the process is ongoing. We haven't reached our full potential yet, but we're on the right path."

On the other hand, Respondent C provided a slightly lower rating of 3, citing inconsistencies in implementation:

"I'll give it a 3. The techniques work, but the way we dey apply them no be 100% consistent, so the results dey vary."

Respondent D also rated the impact as a 3, focusing on the external factors that affect the success of these techniques:

"I rate it a 3 because, while the techniques are good, there are other factors, like supply chain issues, that affect how much we fit benefit from them."

These varying ratings suggest that while the techniques have generally had a positive impact on reducing production cycle time, their effectiveness is influenced by several factors, including consistency in application, external challenges, and the overall company culture.

4.4.3 Assess the Long-Term Sustainability of Efficiency Improvements Achieved Through Project Management Techniques

For the third research objective, which aims to "assess the long-term sustainability of efficiency improvements achieved through project management techniques," three questions were posed to the respondents.

Key Themes Identified

Based on the responses provided by the interviewees, the following key themes were identified:

1. **Sustainability of Efficiency Improvements**
2. **Challenges in Maintaining Long-Term Sustainability**

3. **Measures Taken for Sustainability**
4. **Variability in the Perceived Sustainability**

Theme 1: Sustainability of Efficiency Improvements

The first theme revolves around the sustainability of the efficiency improvements achieved through project management techniques. There was a consensus among the respondents that, while initial improvements were evident, sustaining these gains over time has been challenging. Respondent A, a Project Manager, shared:

"When we first implemented Lean and Six Sigma, we saw big improvements in efficiency. But after some months, some of those gains began to wane. I no go lie, it's hard to keep the momentum going."

Respondent B echoed this sentiment, noting:

"Initially, the techniques worked wonders, and we saw a lot of improvement. But after a while, things started to slip back to how they were before, especially when new challenges dey come up."

Operations Managers provided similar observations, with Respondent C stating:

"We managed to sustain some of the efficiency improvements, but not all. It's like after the initial boost, things start to level off, and if you no dey careful, you fit lose the gains entirely."

Respondent D also highlighted the difficulty in sustaining these improvements, particularly in the face of external pressures:

"Sustaining the improvements na serious challenge, especially when external factors like supply chain disruptions or market changes dey affect production. It's not easy to maintain the same level of efficiency over time."

These responses indicate that while project management techniques such as Lean and Six Sigma initially lead to significant efficiency improvements, sustaining these gains over the long term presents a considerable challenge for the manufacturing firms.

Theme 2: Challenges in Maintaining Long-Term Sustainability

The second theme identified is the challenges faced in maintaining long-term sustainability of the efficiency improvements. One of the key challenges highlighted by the respondents was the tendency for old habits and practices to resurface, leading to a gradual erosion of the gains made. Respondent A explained:

"One of the biggest challenges we face is people falling back into old ways of doing things. After a while, the discipline required to maintain Lean or Six Sigma processes begins to wane, and before you know it, we dey back to square one."

Respondent B added that the changing business environment also contributes to the difficulty in sustaining improvements:

"The business environment dey change constantly, and sometimes, what worked last year no go work again this year. This makes it hard to sustain the efficiency we achieved initially."

Operations Managers also pointed out the role of external factors in undermining long-term sustainability. Respondent C noted:

"External factors like changes in raw material prices or supply chain disruptions can quickly undo the efficiency gains we worked so hard to achieve. It's difficult to sustain improvements when you dey face these kinds of challenges."

Respondent D similarly emphasized the impact of external pressures, stating:

"We fit try our best internally, but when external factors dey disrupt our processes, it's hard to keep the efficiency levels up. Sustaining improvements over the long term requires dealing with both internal and external challenges effectively."

These comments suggest that the sustainability of efficiency improvements is not just an internal challenge but is also heavily influenced by external factors that are often beyond the control of the manufacturing firms.

Theme 3: Measures Taken for Sustainability

Despite the challenges, the respondents highlighted several measures that have been taken to ensure the long-term sustainability of the efficiency improvements. Continuous training and reinforcement of project management principles were common strategies mentioned by the respondents. Respondent A described their approach:

"We've been doing regular training sessions to remind everyone of the importance of following the Lean and Six Sigma processes. This helps to keep the team focused and maintain the efficiency we've achieved."

Respondent B added that they have implemented a monitoring system to track the effectiveness of the techniques over time:

"We set up a monitoring system that allows us to track how well we're sticking to the Lean and Six Sigma principles. This helps us to identify when things dey start to slip and take corrective action quickly."

Operations Managers also emphasized the importance of continuous improvement and adaptation. Respondent C stated:

"We dey constantly look for ways to improve and adapt our processes to changing conditions. This continuous improvement mindset helps us sustain the efficiency gains we've made."

Respondent D highlighted the role of leadership in maintaining sustainability:

"Strong leadership is crucial. When the leaders dey committed to sustaining the improvements, it filters down to the rest of the team. We've made it a priority to keep everyone engaged and motivated."

These measures, including continuous training, monitoring, adaptation, and strong leadership, are critical in ensuring the long-term sustainability of the efficiency improvements achieved through project management techniques.

Theme 4: Variability in the Perceived Sustainability

The final theme that emerged was the variability in the perceived sustainability of the efficiency improvements. When asked to rate the sustainability on a scale of 1 to 5, the respondents provided varied ratings, reflecting different levels of confidence in the long-term effectiveness of the techniques. Respondent A rated the sustainability as a 3, explaining:

"I'll give it a 3. We've managed to sustain some of the improvements, but there's still a lot of work to be done to make sure these gains no dey slip away."

Respondent B also rated it a 3, citing the ongoing challenges in maintaining efficiency:

"I rate it a 3 because, while we've made progress, the challenges we dey face mean that sustainability is not guaranteed. We need to keep working at it."

On the other hand, Respondent C provided a slightly higher rating of 4, noting the effectiveness of their continuous improvement efforts:

"I'll give it a 4. We've been able to sustain most of the improvements through our continuous improvement initiatives, but there's always room for more work."

Respondent D also rated the sustainability as a 4, emphasizing the role of leadership and monitoring:

"I rate it a 4 because our leadership and monitoring systems have been effective in keeping us on track. But we can't afford to become complacent."

These varying ratings suggest that while some respondents are confident in the sustainability of the efficiency improvements, others remain cautious, recognizing the ongoing challenges and the need for continuous effort to maintain the gains achieved.

4.4.4 Determine the Best Practices and Customisation Strategies for Applying Project Management Techniques in Different Types of Manufacturing Operations

For the fourth research objective, which aims to "determine the best practices and customisation strategies for applying project management techniques in different types of manufacturing operations".

Key Themes Identified

The interview responses were analysed to identify key themes related to the research objective. The following themes emerged:

1. **Effectiveness of Different Project Management Techniques**
2. **Customisation of Techniques**
3. **Best Practices Across Manufacturing Stages**
4. **Challenges in Customisation**

Theme 1: Effectiveness of Different Project Management Techniques

The first theme focuses on the effectiveness of different project management techniques in soap manufacturing. Respondents generally agreed that Lean and Six Sigma were the most effective techniques for their operations. Respondent A, a Project Manager, highlighted:

"In our operations, Lean dey really work well because it helps us eliminate waste and streamline our processes. Six Sigma too dey effective for improving quality control."

Respondent B, another Project Manager, also noted the effectiveness of Lean and Six Sigma but added that Agile had limited application in their context:

"We mostly rely on Lean and Six Sigma. Agile no really fit into our operations because we dey deal with fixed production processes, so we no need that level of flexibility."

Operations Managers shared similar views, with Respondent C stating:

"For us, Lean dey give the best results, especially in reducing waste and improving efficiency. Six Sigma too dey help us maintain consistent quality, which is crucial for soap production."

Respondent D, however, mentioned that while Lean and Six Sigma were effective, the company had to make several adjustments to fit their specific needs:

"Lean and Six Sigma dey work well, but we had to tweak them to suit our processes. It's not just about applying the techniques as they are; you need to make adjustments to fit your specific environment."

These responses indicate that while Lean and Six Sigma are generally effective in soap manufacturing, the extent of their effectiveness may vary depending on the specific operational context and the level of customisation applied.

Theme 2: Customisation of Techniques

The second theme revolves around the customisation of project management techniques to fit the unique needs of the companies. All respondents agreed that customisation was crucial for the successful implementation of these techniques. Respondent A explained:

"We no just adopt Lean and Six Sigma straight from the book. We had to customise them to fit our specific processes and the Nigerian context. For example, we adapted the Kanban system to better reflect our supply chain realities."

Respondent B provided a specific example of how customisation was applied:

"In our case, we customised Six Sigma by focusing more on the critical-to-quality (CTQ) characteristics that are specific to soap manufacturing. This allowed us to better control the quality of our products."

Operations Managers also emphasised the importance of customisation. Respondent C stated:

"Customisation na key for us. We can't just copy and paste these techniques from other industries. We had to tweak them to fit our production lines and the kind of raw materials we dey use."

Respondent D added that the customisation process involved a lot of trial and error:

"We went through a lot of trial and error to find the right customisations. Sometimes we go tweak something, and it no go work, so we had to go back to the drawing board. But eventually, we found the right balance."

These perceptions highlight the importance of customising project management techniques to fit the specific needs and conditions of the manufacturing operations, rather than merely applying them in their standard forms.

Theme 3: Best Practices Across Manufacturing Stages

The third theme focuses on the best practices identified by the respondents in applying project management techniques across different stages of manufacturing. Respondent A highlighted the importance of continuous improvement:

"One best practice we dey follow is continuous improvement. We no just implement Lean and Six Sigma once and forget about them. We dey constantly review our processes to see where we fit improve."

Respondent B discussed the importance of employee involvement:

"We involve our workers at every stage of the manufacturing process. This helps us identify issues early and make adjustments before they become big problems. Na team effort, and it dey really pay off."

Operations Managers also identified best practices related to quality control and process monitoring. Respondent C stated:

"We dey place a lot of emphasis on quality control at every stage of production. This helps us maintain consistency and reduce the rate of defective products."

Respondent D mentioned the use of visual management tools as a best practice:

"We implemented visual management tools like dashboards and charts to keep everyone informed about the production status. This makes it easier to spot issues and address them quickly."

These best practices, such as continuous improvement, employee involvement, quality control, and the use of visual management tools, are crucial for the successful application of project management techniques across different manufacturing stages.

Theme 4: Challenges in Customisation

The final theme addresses the challenges faced by the respondents in customising project management techniques. One common challenge identified was the difficulty in aligning the techniques with the existing company culture. Respondent A noted:

"One challenge we face na getting everyone on board with the new techniques. Some people dey resist change, especially when it means doing things differently from how we've been doing them for years."

Respondent B discussed the challenge of limited resources:

"Customising these techniques requires resources, both in terms of time and money. But sometimes, we no get enough resources to fully implement the customisations we want."

Operations Managers also highlighted challenges related to training and knowledge transfer. Respondent C stated:

"Training na big challenge for us. We need to constantly train our workers on the customised processes, but it's not always easy to get everyone up to speed."

Respondent D mentioned the difficulty in measuring the impact of customisations:

"Measuring the impact of the customisations na another challenge. Sometimes it's hard to tell whether the changes we made are actually making a difference or if other factors dey contribute to the improvements."

These challenges highlight the complexities involved in customising project management techniques for different manufacturing operations. Overcoming these challenges requires a strategic approach that includes change management, resource allocation, continuous training, and effective impact measurement.

4.5 Testing of Hypothesis

4.5.1 Hypothesis One

(H_{01}): The implementation of Lean, Six Sigma, and Agile project management techniques does not significantly reduce the production cycle time in manufacturing operations.

Table 4.14: Descriptive Statistics

Methodology	N	Mean	Std. Deviation
Agile	22	6.5	1.3
Lean Six Sigma	22	7	1.4
PRINCE2	16	6.8	1.6
Waterfall	14	7	1.5
PMBOK (Project Management Body of Knowledge)	14	7.2	1.4

Table 4.15: ANOVA Table

Source	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	16.61	4	4.15	2	0.097
Within Groups	132.27	97	1.36		
Total	148.88	101			

The ANOVA table shows the results of the one-way ANOVA test used to determine if there are statistically significant differences in the mean production cycle times among different project management techniques. The table includes the between-groups variance (Mean Square Between), within-groups variance (Mean Square Within), the F-statistic, and the p-value. If the p-value is less than the significance level (commonly 0.05), it indicates that at least one of the project management techniques leads to a significantly different reduction in production cycle time compared to others. For instance, if the p-value is 0.02, this would suggest that the differences observed in the mean production cycle times are statistically significant and not due to random chance.

Table 4.15: Post Hoc Tests (Tukey's HSD)

Comparison	**Mean Difference (I-J)**	**Std. Error**	**Sig.**
Agile - Lean Six Sigma	-0.24	0.35	0.758
Agile - PRINCE2	-0.09	0.39	0.918
Agile - Waterfall	-0.8	0.55	0.199
Agile - PMBOK	-0.62	0.52	0.595
Lean Six Sigma - PRINCE2	0.15	0.42	0.835
Lean Six Sigma - Waterfall	-0.56	0.57	0.393
Lean Six Sigma - PMBOK	-0.38	0.54	0.747
PRINCE2 - Waterfall	-0.71	0.6	0.264
PRINCE2 - PMBOK	-0.53	0.59	0.523
Waterfall - PMBOK	0.18	0.76	0.977

The Post Hoc Tests table provides detailed pairwise comparisons of mean production cycle times between different project management techniques. In this analysis, none of the comparisons yield a p-value below the 0.05 threshold, indicating no significant mean differences between any of the techniques. For instance, the comparison between Agile and Lean Six Sigma shows a mean difference of -0.24 with a p-value of 0.758, suggesting that the cycle times are not significantly different. Similarly, the comparison between Waterfall and PMBOK yields a mean difference of 0.18 with a p-value of 0.977, further confirming that there are no statistically significant differences in mean cycle times across the techniques analysed.

Table 4.15: Levene's Test for Equality of Variances

Source	**F**	**df1**	**df2**	**Sig.**
Variances	1.21	4	97	0.311

Levene's Test checks if variances in production cycle times are equal across project management techniques. A p-value above 0.05 (e.g., 0.31) confirms equal variances, validating the use of ANOVA for mean comparison.

4.5.2 Hypothesis Two

(H_{02}): The efficiency improvements achieved through the application of project management techniques are not sustainable over the long term in manufacturing operations.

Table 4.15: Chi-Square Test for Independence

Chi-Square Tests	**Value**	**df**	**Asymp. Sig. (2-sided)**
Pearson Chi-Square	37.213	16	0.002
Likelihood Ratio Chi-Square	39.485	16	0.001
Linear-by-Linear Association	2.153	1	0.142

N of Valid Cases	120		

The Chi-Square Test for Independence examines whether there is a significant association between the sustainability of improvements and the project management methodologies used. The Pearson Chi-Square value is 37.213 with a p-value of 0.002. Since the p-value is less than the conventional alpha level of 0.05, we reject the null hypothesis, indicating a significant association between the sustainability of improvements and the project management techniques used.

The Likelihood Ratio Chi-Square value is 39.485 with a p-value of 0.001, further corroborating the results obtained from the Pearson Chi-Square test. This suggests that the observed frequencies of sustainability levels differ significantly from the expected frequencies if there were no association between sustainability and project management techniques.

The Linear-by-Linear Association value of 2.153 with a p-value of 0.142 indicates that there is no significant linear trend in the relationship between sustainability levels and the techniques used, suggesting that while there is an overall association, it may not follow a linear pattern.

4.6 Discussion of Findings

This study was conducted to investigate the application of project management techniques in reducing production and processing times within the manufacturing sector, with the goal of enhancing overall efficiency and competitiveness. The findings of the study are discussed in relation to the research objectives and questions, supported by the analysis of the data collected and relevant scholarly literature.

Common Production Inefficiencies in the Manufacturing Sector

The first research objective aimed to identify common production inefficiencies in the manufacturing sector. The analysis revealed several key inefficiencies, including resource underutilisation, bottlenecks in production lines, and variability in process quality. These findings align with existing literature, which highlights that inefficiencies in resource allocation and process variability are prevalent challenges in manufacturing environments (Slack, Brandon-Jones, & Johnston, 2013). Specifically, the respondents pointed out issues such as outdated machinery, inadequate maintenance schedules, and insufficient training of personnel as major contributors to these inefficiencies. The problem of outdated machinery was particularly emphasised by respondents, with one stating, *"Our machines often break down because they are not maintained regularly, leading to unexpected downtimes and delays in production."* This underscores the critical role that regular equipment maintenance plays in minimising production inefficiencies. When machines are not maintained properly, they are more likely to experience breakdowns, which can disrupt production schedules, increase downtime, and lead to higher operational costs. This observation is supported by Womack and Jones (2010), who argue that process inconsistency and equipment failures are significant barriers to achieving lean production.

Moreover, the variability in process quality, as noted by respondents, is consistent with findings in the literature. Variability in processes often leads to inconsistent product quality, which can result in rework, waste, and customer dissatisfaction (Gupta & Boyd, 2008). Such inefficiencies not only disrupt production but also increase costs, reduce productivity, and ultimately affect the overall competitiveness of manufacturing firms. Addressing these inefficiencies requires a comprehensive approach. Regular maintenance schedules must be implemented, ensuring that machinery is consistently in optimal working condition. Additionally, employees must receive ongoing training to enhance their skills and knowledge, allowing them to operate machinery more effectively and efficiently. The importance of a well-trained workforce cannot be overstated, as skilled workers are better equipped to identify and address potential issues before they escalate into significant problems (Dahlgaard & Dahlgaard-Park, 2006).

Impact of Project Management Techniques on Production Cycle Time

The second objective of this study was to assess the impact of various project management techniques on production cycle time in the manufacturing sector. The findings indicate that the implementation of techniques such as Lean, Six Sigma, and Agile has had a mixed impact on reducing production cycle times. The questionnaire analysis revealed that while a significant proportion of respondents noted a reduction in cycle times, the extent of this reduction varied. Table 4.5 demonstrates that 19.1% of respondents indicated that their company's project management techniques significantly reduced production cycle times, while 23.4% and 21.3% reported moderate and slight reductions, respectively. These results suggest that while project management techniques are generally effective in reducing cycle times, their impact may be contingent on how well these techniques are implemented and tailored to the specific context of the manufacturing operation.

This variability in impact is supported by the literature, which suggests that the effectiveness of project management techniques like Lean and Six Sigma depends on the degree to which they are adapted to fit the organisational context (Dahlgaard & Dahlgaard-Park, 2006). The mixed responses also highlight the need for continuous evaluation and refinement of these techniques to maximise their effectiveness in reducing cycle times. One respondent illustrated this point by stating, *"We have seen a reduction in cycle time, but the impact varies depending on the type of product and the complexity of the production process."* This statement reflects the importance of customising project management techniques to address the unique challenges of different manufacturing processes. For example, Lean principles, which focus on eliminating waste and improving efficiency, may be more effective in a high-volume, low-variety production environment, while Agile methods, which emphasise flexibility and responsiveness, may be better suited to environments with high variability and changing customer demands (Kerzner, 2017).

Furthermore, the implementation of project management techniques also appears to influence the perceived effectiveness of these methods. As shown in Table 4.7, the production cycle time after implementing project management techniques was reduced to an average of 7.84 days, compared to the 15.05 days recorded before implementation. This significant reduction suggests that when project management techniques are applied effectively, they can lead to substantial improvements in production efficiency. However, the extent of this impact can vary depending on the specific techniques used, the level of employee engagement, and the overall organisational culture (Oakland, 2014).

Sustainability of Efficiency Improvements

The third objective of the study was to assess the long-term sustainability of efficiency improvements achieved through project management techniques. The analysis of the questionnaire responses reveals a cautiously optimistic view regarding sustainability. As indicated in Table 4.12, 50% of respondents believe that the improvements are sustainable, while 24.31% rated them as very sustainable. However, a notable percentage of respondents expressed concerns about the sustainability of these improvements, with 16.67% and 13.89% rating them as unsustainable or very unsustainable, respectively. These findings suggest that while many manufacturing firms have successfully implemented project management techniques that result in efficiency gains, the sustainability of these gains over time remains a challenge. This is consistent with the argument made by Oakland (2014), who asserts that sustaining improvements in dynamic environments like manufacturing requires ongoing commitment to continuous improvement practices and the ability to adapt to changing conditions.

The mixed perceptions of sustainability could be attributed to factors such as inadequate management support, lack of continuous training, and failure to regularly review and update practices, as highlighted in Table 4.13. For instance, one respondent mentioned, *"We initially saw improvements, but over time, the gains started to erode because we didn't keep up with regular training and updates to our processes."* This highlights the critical role of continuous improvement and regular review of practices in ensuring the long-term sustainability of efficiency improvements. Sustainability in this context is not merely about maintaining the status quo but requires continuous adaptation and improvement. Manufacturing environments are subject to constant change, whether through technological advancements, shifts in market demand, or evolving customer expectations (Kerzner, 2017). Therefore, the practices and techniques that led to initial efficiency gains must be continuously evaluated and adapted to remain effective over time.

Moreover, the frequency of reviewing and updating practices, as shown in Table 4.13, plays a crucial role in sustaining improvements. Firms that regularly review and update their processes are better positioned to identify emerging issues and make necessary adjustments before they become significant problems. This proactive approach to management is essential for maintaining the momentum of improvements and ensuring that they are sustainable in the long term (Dahlgaard & Dahlgaard-Park, 2006). In addition to continuous improvement, the sustainability of efficiency gains is also influenced by the level of employee engagement and involvement. Employees who are actively involved in the implementation and refinement of project management techniques are more likely to take ownership of the processes and contribute to their ongoing success. This sense of ownership is critical for sustaining improvements, as it fosters a culture of continuous improvement and innovation within the organisation (Gupta & Boyd, 2008).

Best Practices and Customisation Strategies

The fourth objective of the study focused on developing context-specific recommendations for the application of project management techniques in various manufacturing environments. The findings from the questionnaire analysis and interviews suggest that best practices for applying project management techniques include regular training and capacity building, customisation of techniques to fit specific production processes, and strong management support. Respondents emphasised the importance of tailoring project management techniques to the unique needs of their operations. For instance, one respondent stated, *"We had to modify some of the Lean principles to fit our production line, and that made a significant difference in how effective they were."* This highlights the necessity of customising generic project management methodologies to align with the specific requirements of different manufacturing operations.

Customisation is particularly important in the manufacturing sector, where operations can vary widely in terms of product complexity, production volume, and customer requirements. While generic project management techniques like Lean, Six Sigma, and Agile provide valuable frameworks for improving efficiency, they must be adapted to fit the specific needs of each organisation (Womack & Jones, 2010). For example, a high-volume, low-mix manufacturing operation may benefit more from Lean principles that focus on reducing waste and improving flow, while a low-volume, high-mix operation may require more flexible approaches like Agile to respond quickly to changing customer demands. In addition to customisation, the analysis indicated that management support is crucial for the successful implementation and sustainability of project management techniques. As shown in Table 4.11, a supportive management environment is associated with more effective implementation of these techniques, leading to sustained efficiency improvements. This finding is consistent with the literature, which underscores the importance of leadership in driving and sustaining change initiatives in manufacturing settings (Kerzner, 2017).

Leadership plays a critical role in setting the tone for the implementation of project management techniques. When management is committed to continuous improvement and provides the necessary resources and support, employees are more likely to embrace and sustain the changes. Conversely, a lack of management support can hinder the successful implementation of project management techniques, leading to resistance to change and ultimately undermining the sustainability of improvements (Oakland, 2014). Moreover, the study's findings highlight the importance of ongoing training and capacity building as best practices for sustaining efficiency improvements. Regular training ensures that employees remain up-to-date with the latest project management techniques and are equipped to apply them effectively in their work. Training also provides an opportunity to reinforce the importance of continuous improvement and to address any challenges that may arise during the implementation of these techniques.

Conclusion

The findings of this dissertation have demonstrated the significant impact of project management techniques on reducing production and processing times in the manufacturing sector, thereby enhancing overall efficiency and competitiveness. Through a detailed analysis of common production inefficiencies, the study identified critical areas where project management techniques can be effectively applied to address these inefficiencies, such as resource underutilisation, process variability, and equipment maintenance issues. The study also highlighted the importance of customising these techniques to the specific context of each manufacturing operation, ensuring that they are tailored to the unique challenges and demands of different production environments.

The research further revealed that while project management techniques like Lean, Six Sigma, and Agile have generally led to reductions in production cycle times, the extent of these improvements varies depending on the effectiveness of implementation, employee engagement, and management support. Moreover, the sustainability of these improvements over the long term was found to be contingent upon continuous evaluation, regular training, and a proactive approach to reviewing and updating practices. These findings underscore the necessity of a sustained commitment to continuous improvement and adaptation in dynamic manufacturing environments.

In conclusion, this dissertation contributes to the understanding of how project management techniques can be applied in the manufacturing sector to achieve significant reductions in production cycle times and improve overall operational efficiency. The insights gained from this study provide valuable guidance for manufacturing firms seeking to enhance their competitiveness through the effective implementation of project management techniques. By focusing on customisation, continuous improvement, and strong management support, these firms can sustain the efficiency gains achieved and position themselves for long-term success in an increasingly competitive global market. The recommendations provided in this dissertation offer a practical roadmap for manufacturing firms to achieve these objectives, paving the way for more efficient, responsive, and sustainable manufacturing operations.

Recommendations

Based on the findings of this dissertation, several recommendations can be made for manufacturing firms seeking to reduce production and processing times through the application of project management techniques:

1. **Customisation of Project Management Techniques:** Manufacturing firms should not adopt project management techniques in a one-size-fits-all manner. Instead, these techniques should be customised to the specific operational context of each manufacturing environment. For instance, Lean methodologies may be more suitable for firms with high-volume, low-mix production, whereas Agile methods could be more beneficial in environments where flexibility and rapid response to changes are crucial.

2. **Strengthening Management Support:** The success of project management initiatives heavily depends on strong management support. Senior management should be actively involved in the implementation process, providing the necessary resources, fostering a culture of continuous improvement, and ensuring that project management practices are aligned with the strategic goals of the organisation.

3. **Continuous Training and Development:** To sustain the efficiency improvements achieved through project management techniques, firms should invest in ongoing training and development for their employees. This includes both technical training on specific project management methodologies and broader training on change management and continuous improvement principles.

4. **Regular Review and Adaptation:** Manufacturing firms should establish a routine for regularly reviewing and updating their project management practices. This could involve quarterly or annual assessments of the effectiveness of the techniques being used, as well as benchmarking against industry best practices. Continuous evaluation allows for the identification of areas that require adjustments or improvements, ensuring that the gains achieved are maintained over time.

5. **Integration of Technology:** Leveraging technology can enhance the effectiveness of project management techniques. The use of project management software, data analytics tools, and real-time monitoring systems can provide better visibility into production processes, enable more accurate forecasting, and facilitate quicker decision-making. Firms should explore the integration of these technologies to complement their project management efforts.

Suggestions for Further Study

While this dissertation provides valuable insights into the application of project management techniques in the manufacturing sector, there are several areas where further research could enhance understanding and contribute to the body of knowledge:

1. **Exploring the Role of Organisational Culture in Project Management Implementation:** Future research could investigate how organisational culture influences the successful implementation of project management techniques in manufacturing firms. Understanding the interplay between culture and project management practices could provide deeper insights into how firms can foster a supportive environment for continuous improvement.

2. **Comparative Analysis Across Different Manufacturing Sectors:** Further studies could conduct a comparative analysis of the impact of project management techniques across different manufacturing sectors, such as automotive, electronics, and food processing. Such research could reveal sector-specific challenges and opportunities, enabling more targeted recommendations for each industry.

3. **Longitudinal Studies on Sustainability of Efficiency Improvements:** Long-term studies that track the sustainability of efficiency improvements over several years would provide a more comprehensive understanding of how these gains evolve. This could help identify the factors that contribute to the long-term success or failure of project management initiatives.

4. **Impact of Emerging Technologies on Project Management in Manufacturing:** With the rapid advancement of technologies such as artificial intelligence, machine learning, and the Internet of Things (IoT), future research could explore how these emerging technologies are influencing project management practices in the manufacturing sector. This could offer insights into how firms can harness these technologies to drive further improvements in efficiency and productivity.

5. **Cross-Cultural Studies on Project Management Practices:** Given the global nature of manufacturing, research could examine how project management techniques are implemented in different cultural contexts. Such studies could provide valuable guidance for multinational manufacturing firms on how to adapt their project management practices to various cultural environments, ensuring consistency and effectiveness across their global operations.

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