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

**CHAPTER ONE**

**INTRODUCTION**

**1.0 Background to the Study**

The manufacturing sector remains the biggest driver of economic development and industrialization, 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. When compared to the global economic landscape, only seven countries China, Japan, Germany, India, the United Kingdom, France, and the United States itself—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.

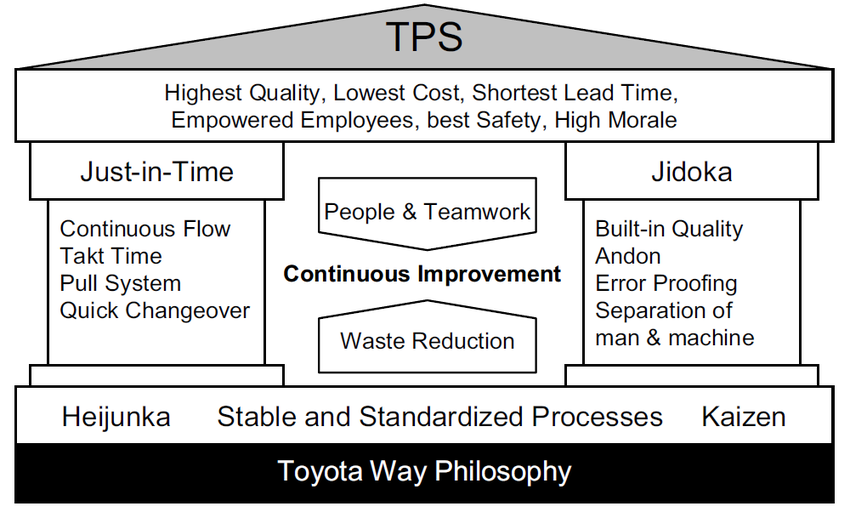


Fig 1: The core principle of the Toyota Production System (Herrmann et al, 2008)

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).

**1.1 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 because 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).

**1.2 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 analysing 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.

**1.3 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. **Research Objectives**

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

**1.3.2 Research Questions**

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

**CHAPTER TWO**

**LITERATURE REVIEW**

**2.0 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.

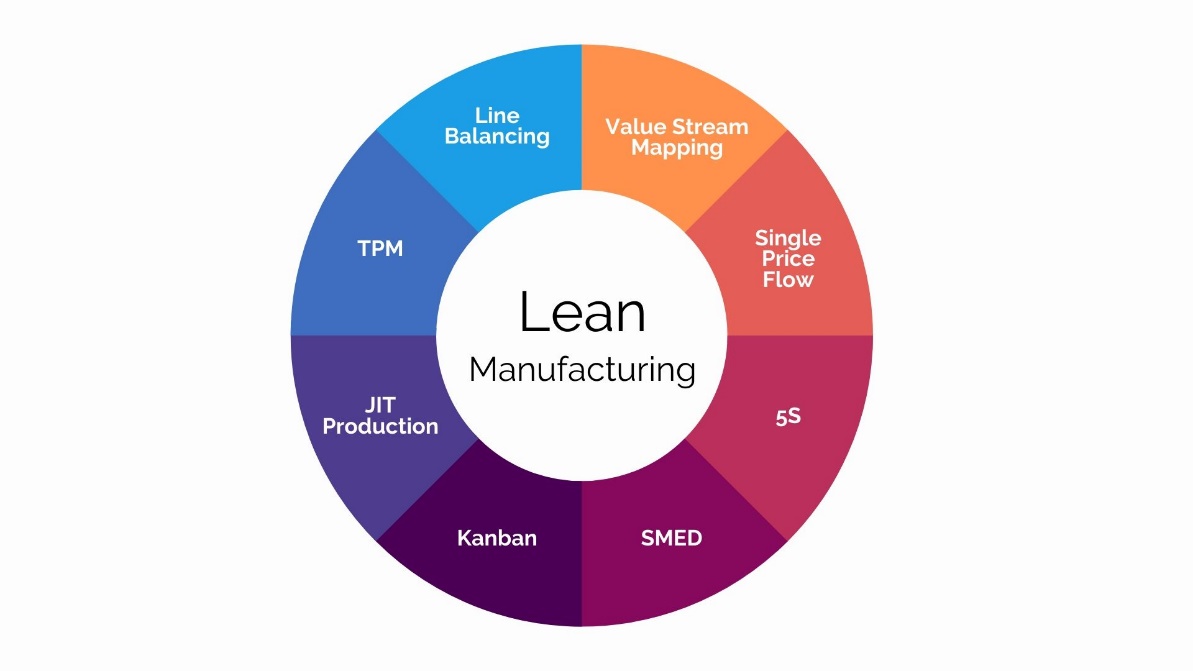


Fig 2: Lean Manufacturing

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.

**2.2 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).

**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.

**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.

**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.

**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.

**2.5 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.

**Conclusion**

In conclusion, the literature review underscores 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 analysed 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 were 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.

## **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).

## **3.3 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 INTEPRETATIONS OF FINDINGS**

# 4.0 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 in the manufacturing. The chapter includes both statistical 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 insights into the effectiveness, adaptation, and challenges of applying project management techniques in manufacturing operations.

# 4.1 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** | Automotive | 17 | 18.09% |
|  | Electronics | 22 | 23.40% |
|  | Food Processing | 24 | 25.53% |
|  | Metal Processing | 16 | 17.02% |
|  | Plastics | 15 | 15.96% |
| **Number of Employees** | Less than 50 | 14 | 14.89% |
|  | 50-100 | 19 | 20.21% |
|  | 101-500 | 25 | 26.60% |
|  | 501-1000 | 18 | 19.15% |
|  | More than 1000 | 18 | 19.15% |

The analysis of the questionnaire data offers valuable insights into the demographics, behaviours, and preferences of the respondents, thereby laying a solid foundation for understanding the workforce and operational landscape within the manufacturing sector.

**Job Titles**

The distribution of job titles among respondents provides insight into the critical roles within the manufacturing sector. Project Managers, comprising 29.79% of the sample, highlight the importance of structured oversight in manufacturing. Their significant presence underscores the necessity for effective project management to align production goals with organizational objectives. Project Managers are essential for managing resources, meeting deadlines, and handling the complexities of manufacturing processes. According to the Project Management Institute (PMI, 2021), effective project management enhances productivity and reduces costs, crucial in a competitive market.

Factory Workers, representing 27.66% of the respondents, are central to daily manufacturing operations. They transform managerial and engineering plans into tangible products, illustrating the labour-intensive nature of the sector. The high proportion of factory workers emphasizes the reliance on skilled personnel for maintaining operational efficiency. This role is vital for the seamless execution of production activities and supports the overall manufacturing process.

Engineers, making up 23.40% of the respondents, reflect the sector’s reliance on technical expertise. They are crucial for designing, improving, and troubleshooting manufacturing systems. Engineers contribute to innovation, quality control, and process optimization, which are essential for staying competitive globally. Their role is vital for implementing technical solutions and advancements in manufacturing processes (Kerzner, 2017).

Operations Managers, constituting 19.15% of the respondents, oversee the entire production process. Their role involves coordinating various departments to meet production targets and improve efficiency. The presence of a significant number of operations managers highlights the importance of leadership in streamlining processes and reducing waste. This diverse distribution of job titles reveals the sector's need for a balanced approach combining strategic oversight and hands-on production, which is essential for reducing production and processing times (Crawford, 2019).

**Years in Manufacturing**

The distribution of experience among respondents—22.34% with 1-3 years and 23.40% with over 10 years in the manufacturing sector—demonstrates a dynamic workforce blending fresh perspectives with seasoned expertise. This combination is essential for fostering both innovation and operational stability. Research shows that a balanced workforce, integrating the agility of newer employees with the deep institutional knowledge of veterans, benefits organizations significantly (Harrison & Lock, 2017).

Newer employees often introduce contemporary skills and a readiness to embrace change, crucial in a sector that is rapidly integrating advanced technologies and methodologies. Their fresh approach is vital for innovation and adapting to new industry trends. In contrast, experienced professionals offer valuable insights and mentorship, which helps accelerate the learning curve for less experienced team members (Brewster et al., 2016).

The presence of varied experience levels within the workforce enhances knowledge transfer, which is critical for organizations to adapt swiftly to market changes and technological advancements. This adaptability is key for reducing production and processing times, as it enables firms to implement improvements more efficiently and effectively (Nonaka & Takeuchi, 1995).

**Type of Manufacturing**

The survey results reveal a diverse range of manufacturing types, with Food Processing leading at 25.53% of respondents, indicating its significant role in the sector. This high representation suggests a robust demand for processed food products and highlights the industry's adaptability to food safety regulations and need for consistent innovation. Electronics manufacturing follows at 23.40%, reflecting its crucial role in the modern economy. The sector's rapid technological advancements and complex supply chains position it as a key driver of growth and innovation.

Automotive manufacturing, representing 18.09% of respondents, underscores its ongoing importance. The focus on innovations such as electric vehicles and automation contributes to this sector’s significant representation. The automotive industry's influence extends to related sectors like metal processing and plastics, amplifying its overall impact on the manufacturing ecosystem.

Metal Processing and Plastics manufacturing, with 17.02% and 15.96% representation, respectively, are foundational to various other manufacturing types. They supply essential materials and components for a wide range of products. This distribution highlights their vital role in supporting diverse manufacturing processes and underscores the interconnected nature of different sectors within the industry.

The analysis of respondents' years of experience reveals a mix of seasoned professionals and newcomers. Those with over 10 years of experience constitute 23.40% of the workforce, bringing extensive industry knowledge and expertise. This experienced group likely holds key positions, contributing to decision-making and maintaining standards. Conversely, 15.96% of respondents have less than 1 year of experience, indicating ongoing recruitment and the sector’s appeal to new talent. Respondents with 1-3 years of experience (22.34%) are developing specialized skills, while those with 4-6 years (20.21%) and 7-10 years (18.09%) provide a balance of technical skills and practical experience, ensuring continuity and adaptability in the industry.

**Number of Employees**

The survey results highlight a diverse range of company sizes within the manufacturing sector. Firms with 101-500 employees are the most represented, comprising 26.60% of respondents. This mid-sized category suggests a prevalent segment in the industry, capable of balancing operational efficiency with flexibility. These companies often have the agility to innovate and adapt while maintaining a manageable scale for effective oversight and quality control.

Companies with 501-1000 employees and those with over 1000 employees each account for 19.15% of respondents. These larger organizations benefit from economies of scale, enabling cost-effective high-volume production and competitive positioning in global markets. Their significant presence reflects the sector's ability to support extensive operations and manage complex supply chains and large workforces.

On the smaller end, firms with 50-100 employees and those with fewer than 50 employees represent 20.21% and 14.89% of respondents, respectively. The inclusion of smaller firms underscores the sector's inclusivity, supporting small and medium enterprises (SMEs) that may focus on niche markets or specialized products. Smaller firms are noted for their agility and ability to swiftly respond to market demands and innovations.

# 4.2 Analysis of Research Objectives

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

## 4.3.1 Common Production inefficiencies in the manufacturing sector

*Table 4.2:*

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **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 4.3:*

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **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 4.4:*

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **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 |

The analysis of production inefficiencies in the manufacturing sector reveals several critical areas where operational effectiveness and profitability are compromised. A key finding from the survey data is the inconsistent application of project management techniques. As indicated by Table 1, only 29.8% of respondents reported that their companies consistently use project management techniques, with a mean score of 2.47. This suggests a significant underutilization of structured management practices, which are essential for streamlining production processes, ensuring proper resource allocation, and adhering to project timelines. The lack of consistent application can lead to poor coordination, increased operational costs, and ultimately, hindered production efficiency (Meredith & Mantel, 2017).

Another significant contributor to production inefficiencies is the choice and implementation of project management methodologies. According to the survey results shown in Table 2, Lean Six Sigma is the most used methodology, with a mean score of 2.91, followed by Agile and PRINCE2. Lean Six Sigma’s focus on waste reduction and process optimization makes it particularly suitable for manufacturing environments where efficiency is paramount. However, the benefits of these methodologies are highly contingent on proper implementation and alignment with organizational needs. Inadequate training or misalignment can negate the potential advantages of these methodologies, leading to persistent inefficiencies (Albliwi et al. 2014). Therefore, manufacturers must not only adopt these methodologies but also ensure that their workforce is adequately trained to implement them effectively.

The effectiveness of project management techniques in improving production processes is another area of concern, as highlighted in Table 3. The mean effectiveness score of 2.79 indicates a moderately positive impact, with 24.5% of respondents rating these techniques as very effective. However, the significant portion of respondents who rated the techniques as neutral (19.1%) or ineffective (29.8%) points to ongoing challenges in fully realizing the potential benefits of project management in manufacturing. Ineffective project management can result in miscommunication, unclear objectives, and a lack of accountability, all of which contribute to delays and increased costs (Kerzner, 2017). This underscores the need for manufacturers to critically assess their project management practices and seek ways to enhance their effectiveness, possibly through adopting more comprehensive and tailored approaches.

## 4.3.2 assess the Impact of Project Management Techniques on Production Cycle Time in the Manufacturing Sector

*Table 4.5:*

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **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 |

*Table 4.6:*

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **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:*

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **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 |

*Table 4.8:*

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **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 survey results reveal a nuanced impact of project management techniques on production cycle times, with an average mean score of 2.88, indicating a moderate reduction. Specifically, 19.1% of respondents reported a significant reduction, while 23.4% noted a moderate reduction. However, 21.3% perceived no impact, and 14.9% experienced increased cycle times. This variation highlights the effectiveness of project management techniques in some contexts but also underscores that not all implementations achieve the desired outcomes (Kerzner, 2017). The mixed results suggest that while project management can enhance efficiency, its impact is contingent upon various factors, including the specific techniques used and their execution.

Examining production cycle times before and after the implementation of project management techniques reveals a substantial improvement. Before applying these techniques, the average cycle time was 15.05 days, with 56.12% of respondents reporting times between 16 and 20 days. Post-implementation, the average cycle time decreased to 7.84 days, with 52.08% of respondents now reporting times between 5 and 7 days. This significant reduction underscores the potential of project management techniques to streamline processes and enhance operational efficiency (PM Solutions, 2018). The data aligns with existing research, which suggests that effective project management can lead to considerable time savings and improved production performance.

The survey also evaluated the impact of specific project management areas, including project scheduling and planning, risk management, resource allocation, quality management, and communication management. Quality management received the highest mean score of 3.22, indicating a significant impact on reducing production cycle times. This finding is consistent with the principles of Total Quality Management (TQM), which emphasize that quality improvements can lead to reduced cycle times and enhanced customer satisfaction (Deming, 1986). Conversely, risk management and resource allocation received lower mean scores, suggesting that these areas might require additional focus to optimize their effectiveness in reducing cycle times (Crawford, 2019).

Despite the overall positive impact, the presence of respondents who reported no impact or increased cycle times suggests that the application of project management techniques is not uniformly successful. Factors such as inadequate training, lack of stakeholder engagement, and insufficient integration into daily operations may contribute to these challenges (Meredith & Mantel, 2017). Addressing these issues is crucial for improving the effectiveness of project management techniques and ensuring that they deliver consistent benefits across different organizational contexts.

## 4.3.3 assess the long-term sustainability of efficiency improvements achieved through project management techniques

*Table 4.9:*

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **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 |

*Table 4.10:*

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **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 4.11:*

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **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 |

Evaluating the long-term sustainability of efficiency improvements achieved through project management techniques is essential for determining their enduring impact. The survey data reveals a moderate level of project management tool usage, with a mean rating of 3.28. Specifically, 36.46% of respondents use these tools sometimes, while 38.54% use them often or always. Despite this, 18.75% of respondents never use these tools, and 27.08% use them rarely. This distribution indicates that although project management tools are integrated into many organizations, a significant portion may not fully utilize these resources, which could affect the long-term sustainability of their improvements. Effective use of project management tools is crucial as they aid in planning, monitoring, and controlling processes, which are essential for sustaining improvements over time (Kerzner, 2017).

Barriers to implementing project management techniques are significant factors impacting the perceived sustainability of efficiency improvements. The mean rating for these barriers is 3.33, with high implementation costs (42.43%) and inadequate training (33.33%) identified as major obstacles. A lack of skilled personnel (32.56%) also contributes to the difficulties in applying project management techniques effectively. These barriers can impede the successful adoption of project management practices and influence the long-term sustainability of efficiency gains. Addressing these challenges through targeted investments in training and development is essential for overcoming these barriers and ensuring that initial improvements are sustained (Meredith & Mantel, 2017).

Management support is another critical factor affecting the sustainability of efficiency improvements. The survey indicates that management support has a mean rating of 2.89, reflecting a generally neutral to unsupportive stance. A significant proportion of respondents perceive management support as neutral (25.00%) or unsupportive (34.72%), with only 18.06% viewing it as very supportive. Strong management support is crucial for the successful implementation and sustainability of project management techniques. Research highlights that active and committed management involvement is necessary for fostering a culture of continuous improvement and integrating project management practices effectively into the organizational framework (Crawford, 2019).

## 4.3.4 assess long term sustainability of the efficiency improvements achieved through the application of project management techniques

*Table 4.12:*

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **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 4.13:*

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **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 |

Assessing the long-term sustainability of efficiency improvements achieved through project management techniques is essential for understanding their enduring impact. The survey data reveals a mixed perception of sustainability, with a mean rating of 3.3 out of 5. This suggests a moderate level of optimism among respondents about the sustainability of these improvements. While half of the respondents view the improvements as sustainable, there is a significant proportion of respondents who remain uncertain or sceptical about their long-term viability. This disparity highlights the need for continued monitoring and evaluation to ensure that efficiency gains are not only achieved but also maintained over time.

The survey findings show that 50% of respondents consider the improvements sustainable, and 24.31% view them as very sustainable. However, 30.56% of respondents rated the sustainability of these improvements as neutral, unsustainable, or very unsustainable. This mixed feedback underscores the importance of addressing the concerns of those who perceive the improvements as less sustainable. To enhance the overall perception and effectiveness of these initiatives, it is crucial to implement robust mechanisms for ongoing evaluation and address any identified issues that might undermine long-term sustainability.

Further analysis of the frequency with which practices are reviewed and updated reveals a mean rating of 2.92, indicating less frequent reviews. Specifically, 38.19% of respondents update their practices quarterly, and 22.92% do so monthly, while 15.28% never review their practices. This infrequency could contribute to the mixed perceptions of sustainability. Regular and systematic reviews are essential for identifying potential issues and ensuring that improvements remain effective and relevant over time (PMI, 2020). Regular reviews help organizations adapt to changing conditions and maintain the momentum of efficiency gains.

The survey results indicate that a significant portion of respondents, 50%, view the improvements achieved through project management techniques as sustainable. This perception is vital as it reflects the confidence of organizations in their ability to maintain efficiency gains long-term. However, the presence of 29.17% of neutral responses and 16.67% of respondents who see the improvements as unsustainable suggests a need to address underlying barriers to ensure lasting success. These barriers may include inadequate training, lack of skilled personnel, and insufficient management support, which have been identified as critical factors in the successful implementation of project management techniques (Meredith & Mantel, 2017).

# 4.4 Testing of Hypothesis

# 4.4.1 Hypothesis One

**(H₀₁):** 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.

# 4.4.2 Hypothesis Two

**(H₀₂)**: 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.

# 4.5 Thematic Analysis of Interview Responses

## 4.5.1 Objective 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 really 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).

**Conclusion**

The thematic analysis of the interview responses reveals several critical factors contributing to production inefficiencies in the Nigerian manufacturing sector. These include inadequate infrastructure and equipment, human resource challenges, supply chain disruptions, and technological limitations. The analysis shows that while all respondents acknowledge these issues, their perspectives vary depending on their roles within the organization. Project Managers tend to focus more on technical and training-related aspects, while Operations Managers emphasize human resource and supply chain issues. These findings suggest that addressing production inefficiencies will require a multi-faceted approach that considers both the technical and managerial aspects of manufacturing processes. Additionally, there is a need for greater investment in training, technology, and supply chain management to mitigate these inefficiencies and enhance productivity.

## 4.5.2 Objective 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, consisting of two Project Managers and two Operations Managers from two different soap manufacturing companies in Nigeria. The questions were:

1. **Which project management techniques (e.g., Lean, Six Sigma, Agile) are currently used in your manufacturing processes?**
2. **How have these techniques affected your production cycle times? Can you provide specific examples?**
3. **On a scale of 1 to 5, how would you rate the impact of these techniques on reducing production cycle time?**

**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.

**Conclusion**

The thematic analysis of the interview responses for the second research objective highlights the adoption of Lean and Six Sigma as the primary project management techniques in the soap manufacturing sector in Nigeria. These techniques have led to improvements in production cycle time, though the extent of these improvements varies across different firms and is influenced by factors such as consistency in application, training, and external challenges. The responses also reveal that while the techniques are beneficial, their full potential is often not realized due to implementation challenges and the need for cultural alignment within the organizations. This analysis suggests that to further reduce production cycle times, manufacturing firms need to focus on addressing these challenges, ensuring consistent application of the techniques, and continuously adapting to external factors that may impact their effectiveness.

## 4.5.3 Objective 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. The respondents consisted of two Project Managers and two Operations Managers from two different soap manufacturing companies in Nigeria. The questions were:

1. **Have the efficiency improvements achieved through project management techniques been sustained over time? Why or why not?**
2. **What measures have been taken to ensure the long-term sustainability of these improvements?**
3. **On a scale of 1 to 5, how would you rate the sustainability of the efficiency improvements?**

**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.

**Conclusion**

The thematic analysis of the interview responses for the third research objective highlights the mixed experiences of the respondents in sustaining the efficiency improvements achieved through project management techniques. While initial gains were significant, maintaining these improvements over the long term has proven challenging due to factors such as the reversion to old practices, changes in the business environment, and external pressures. The respondents identified several measures taken to ensure sustainability, including continuous training, monitoring, adaptation, and strong leadership. However, the variability in the perceived sustainability of these improvements underscores the ongoing nature of the challenge and the need for continuous effort to maintain the gains achieved. This analysis suggests that manufacturing firms need to remain vigilant and proactive in sustaining the efficiency improvements achieved through project management techniques, particularly in the face of external and internal challenges.

## 4.5.4 Objective 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," the following interview questions were posed to the respondents:

1. **What project management techniques (e.g., Lean, Six Sigma, Agile) have you found most effective in your soap manufacturing processes?**
2. **How have you customised these techniques to fit the unique needs of your company?**
3. **What best practices have you identified in applying these techniques across different stages of manufacturing?**

The respondents included two Project Managers and two Operations Managers from two different soap manufacturing companies in Nigeria.

**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 insights underscore 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 adjust 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.

**Conclusion**

The thematic analysis of the interview responses for the fourth research objective provides valuable insights into the best practices and customisation strategies for applying project management techniques in soap manufacturing. The respondents identified Lean and Six Sigma as the most effective techniques but emphasised the need for customisation to fit the specific needs of their operations. Best practices such as continuous improvement, employee involvement, quality control, and the use of visual management tools were highlighted as key factors for success. However, the respondents also faced challenges in customisation, including resistance to change, limited resources, training difficulties, and measuring impact. These findings suggest that while project management techniques can be highly effective in improving manufacturing operations, their success largely depends on the ability to customise them to the specific context and overcome the associated challenges.

# **CHAPTER FIVE: SUMMARY OF FINDINGS, CONCLUSIONS AND RECOMMENDATION**

# 5.1 INTRODUCTION

This chapter consists of a summary of major findings, answers to research questions, conclusion and recommendation of the study.

# 5.2 Summary of Major Findings

## 5.2.1 Common Production Inefficiencies in Manufacturing

The study highlights four major inefficiencies affecting the manufacturing sector: inadequate infrastructure and equipment, human resource challenges, supply chain disruptions, and technological limitations. Each of these factors significantly impedes production efficiency and operational effectiveness, reflecting broader issues in the sector.

**Inadequate Infrastructure and Equipment** is a critical inefficiency, as identified through both thematic and survey data. Survey results (Table 4.2) reveal that only 29.8% of companies consistently use project management techniques, suggesting a widespread lack of structured practices to address infrastructure issues. Interviews corroborate this, with respondents highlighting outdated machinery and inconsistent power supply as major obstacles (Respondent A and B). This inadequacy not only hampers production speed but also leads to frequent breakdowns and delays. The findings align with Meredith and Mantel (2012), who assert that outdated infrastructure directly contributes to inefficiencies by causing frequent production halts and increased operational costs.

**Human Resource Challenges** also emerge as a significant inefficiency. Data from Table 4.4 and interview responses reveal a gap in the training and management of workers. Operations Managers emphasize issues such as insufficient training and lack of discipline (Respondent C and D). This misalignment between training and job requirements results in errors and delays, which are compounded by inadequate management practices. Albliwi et al. (2014) supports this view, indicating that without adequate training and effective management, the benefits of advanced project management methodologies are undermined, perpetuating inefficiencies.

**Supply Chain Disruptions** are another critical issue affecting production efficiency. Survey data and interviews highlight delays in raw material supply and inconsistent delivery schedules as major problems (Respondent A and D). These disruptions lead to production bottlenecks and increased downtime, affecting overall output. The study’s findings are consistent with Aloini et al. (2012)and Fernandez-Viagas and Framinan (2015), who argue that robust supply chain management systems are essential for maintaining production efficiency and mitigating the impact of external disruptions.

**Technological Limitations** further compound these inefficiencies. Respondents indicate difficulties in integrating new technologies with existing systems (Respondent C and B). This slow pace of technological adoption limits the potential for operational improvements and leaves firms lagging competitors. Durakovic (2018) and Panayiotou et al. (2022) highlight the importance of continuous technological upgrades to enhance production capabilities and maintain competitiveness. The reluctance or inability to invest in the latest technologies thus becomes a significant barrier to achieving operational excellence.

Addressing these production inefficiencies requires a comprehensive approach that integrates improvements in infrastructure, human resources, supply chain management, and technology. The study reveals that while each inefficiency individually impacts production, their combined effect underscores a need for strategic investment and management changes. Firms must prioritize updating infrastructure, investing in workforce training, enhancing supply chain resilience, and adopting new technologies to overcome these challenges and improve overall production efficiency. The findings provide a clear path for addressing these inefficiencies through targeted interventions and strategic investments, ultimately contributing to enhanced productivity and operational effectiveness in the manufacturing sector.

## 5.2.2 Impact of Project Management Techniques on Production Cycle Times

The survey data indicates a significant but varied impact of project management techniques on production cycle times in the manufacturing sector. The findings, with an average mean score of 2.88, suggest a moderate reduction in cycle times due to the application of project management practices. Specifically, 19.1% of respondents noted a significant reduction, while 23.4% reported a moderate reduction. However, 21.3% observed no impact, and 14.9% even experienced increased cycle times. This variation underscores that while project management techniques can enhance operational efficiency, their effectiveness is not uniform and depends on various factors, including the methods used and their implementation quality (Kerzner, 2017).

Before implementing project management techniques, the average production cycle time was 15.05 days, with most respondents reporting cycle times between 16 and 20 days. After implementation, this average dropped to 7.84 days, with most respondents now experiencing cycle times between 5 and 7 days. This substantial reduction highlights the potential of project management methodologies to streamline production processes and improve efficiency (PM Solutions, 2018). The data aligns with existing literature, which suggests that effective project management can lead to significant time savings and better production performance. For instance, Lean techniques focus on waste reduction and process optimization, which can substantially shorten cycle times if implemented effectively (Womack & Jones, 2003).

The survey also assessed the impact of various project management areas, such as project scheduling and planning, risk management, resource allocation, quality management, and communication management. Quality management received the highest mean score of 3.22, indicating a notable impact on reducing production cycle times. This supports the principles of Total Quality Management (TQM), which assert that quality improvements can lead to faster production cycles and enhanced customer satisfaction (Deming, 1986). In contrast, risk management and resource allocation received lower mean scores, suggesting that these areas may require more focus to fully realize their potential in reducing cycle times (Crawford, 2019). This discrepancy highlights that while some project management aspects are effective, others may need refinement or better integration into organizational practices.

The presence of respondents reporting no impact or increased cycle times suggests that the success of project management techniques is not guaranteed. Factors such as inadequate training, insufficient stakeholder engagement, and poor integration into daily operations may contribute to these challenges (Meredith & Mantel, 2017). For instance, Lean and Six Sigma techniques require a deep understanding and commitment from all levels of the organization to be truly effective. Without proper training and buy-in, the potential benefits of these methodologies can be undermined. Addressing these issues and ensuring that project management techniques are appropriately adapted and integrated can enhance their effectiveness and ensure consistent improvements in production cycle times across different manufacturing contexts.

While project management techniques like Lean, Six Sigma, and Agile have the potential to significantly reduce production cycle times, their impact is influenced by how well they are implemented and integrated. The findings underscore the importance of not only adopting these methodologies but also ensuring comprehensive training, stakeholder engagement, and continuous improvement to achieve optimal results.

## 5.2.3 Sustainability of Efficiency Gains

The assessment of the long-term sustainability of efficiency improvements achieved through project management techniques in manufacturing operations reveals a nuanced picture. Survey data and qualitative interviews indicate that while project management techniques like Lean and Six Sigma initially drive substantial efficiency gains, maintaining these improvements over time is fraught with challenges. The survey results present a mixed perception of sustainability. With a mean rating of 3.3, respondents exhibit moderate optimism regarding the long-term effectiveness of these improvements. Although half of the respondents view the improvements as sustainable, there remains a notable proportion who are sceptical, suggesting that the efficiency gains may not be uniformly maintained across all organizations.

Key findings from the survey data and interviews highlight several critical factors affecting the long-term sustainability of these improvements. The survey data indicates that the usage of project management tools is moderate but not universal, with a significant percentage of respondents either never using or rarely using these tools. This uneven application could undermine the sustainability of efficiency gains, as effective utilization of these tools is crucial for ongoing improvement and adaptation. Furthermore, barriers such as high implementation costs, inadequate training, and lack of skilled personnel were identified as major impediments to achieving long-term sustainability. High costs and insufficient training can hinder the effective adoption of project management techniques, while a shortage of skilled personnel can impede the successful application and maintenance of these practices.

Interviews with Project and Operations Managers corroborate these findings, emphasizing that sustaining efficiency improvements is often challenged by the reversion to old practices and external pressures such as supply chain disruptions. Respondents reported that while initial improvements are noticeable, maintaining these gains requires continuous effort and adaptation. Key measures identified to address these challenges include regular training, robust monitoring systems, and strong leadership. These measures are vital for reinforcing the principles of project management and ensuring that efficiency improvements remain effective over time. The variability in perceived sustainability among respondents further underscores the complexity of sustaining efficiency improvements, with some organizations managing to maintain gains effectively while others struggle.

The study indicates that while project management techniques can significantly enhance efficiency in the short term, their long-term sustainability is not guaranteed and requires ongoing effort. Organizations must address barriers to implementation, invest in continuous training, and adapt to both internal and external challenges to maintain these improvements. The mixed perceptions of sustainability reflect the need for a proactive and adaptive approach to project management, emphasizing that sustained success is contingent upon continuous reinforcement and management commitment. As manufacturing firms navigate these challenges, they must remain vigilant and responsive to ensure that efficiency gains achieved through project management techniques are preserved and built upon over time.

## 5.2.4 Best Practices and Customisation Strategies in Manufacturing

The analysis of best practices and customization strategies for applying project management techniques in various manufacturing operations provides valuable insights into enhancing efficiency and effectiveness. The study, based on interviews with Project and Operations Managers from soap manufacturing companies in Nigeria, reveals key themes that highlight the practical application of techniques such as Lean, Six Sigma, and Agile. These findings underscore the importance of customizing project management practices to fit the unique needs of different manufacturing contexts and identify several best practices crucial for sustaining improvements.

**Effectiveness and Customization of Techniques**

The research identifies Lean and Six Sigma as the most effective project management techniques in soap manufacturing. Respondents praised Lean for its role in eliminating waste and streamlining processes, and Six Sigma for its ability to improve quality control. For instance, Respondent A noted the significant impact of Lean in reducing waste, while Respondent B emphasized Six Sigma’s effectiveness in maintaining quality. Conversely, Agile was deemed less applicable due to the fixed nature of soap production processes, which do not benefit from Agile's flexibility. This finding supports the assertion that while certain techniques may be broadly effective, their applicability can vary significantly based on the production environment and operational needs. Customization emerged as a crucial factor for maximizing the effectiveness of these techniques. Respondents highlighted the need to adapt Lean and Six Sigma to the specific operational context, such as modifying the Kanban system to align with supply chain realities. Customization allows for more precise control over critical aspects of production and quality, tailored to the specific requirements of soap manufacturing.

**Best Practices Across Manufacturing Stages**

The study also highlights several best practices that are essential for the successful application of project management techniques across different manufacturing stages. Continuous improvement is identified as a key practice, with Respondent A emphasizing the importance of regularly reviewing and refining processes. This practice ensures that improvements are not static but evolve in response to ongoing operational challenges and opportunities. Another critical best practice is involving employees in the manufacturing process. As noted by Respondent B, engaging workers at every stage helps identify and resolve issues early, fostering a collaborative approach to problem-solving. Additionally, robust quality control measures and the use of visual management tools were identified as effective strategies. Respondent C emphasized the role of quality control in maintaining product consistency, while Respondent D highlighted the value of visual management tools in monitoring production status and quickly addressing issues. These practices collectively contribute to sustaining efficiency and effectiveness by fostering a culture of continuous improvement, enhancing communication, and ensuring high standards of quality.

**Challenges in Customization**

Despite the benefits of customization, several challenges were reported. Aligning new techniques with existing company culture often encounters resistance, as noted by Respondent A, who observed reluctance to change among employees. Limited resources, both in terms of time and money, also pose significant barriers to effective customization, as highlighted by Respondent B. These challenges are compounded by difficulties in training and knowledge transfer, with Respondent C identifying training as a persistent issue. Furthermore, measuring the impact of customizations can be complex, as mentioned by Respondent D, making it challenging to evaluate whether changes are yielding the desired improvements. Addressing these challenges requires a strategic approach that includes comprehensive change management practices, adequate resource allocation, ongoing training, and effective methods for impact measurement.

The findings from the study provide a clear picture of the best practices and customization strategies necessary for effectively applying project management techniques in manufacturing operations. Lean and Six Sigma are highlighted as effective techniques, though their success largely depends on proper customization to fit specific operational needs. Best practices such as continuous improvement, employee involvement, quality control, and visual management tools play a crucial role in maintaining and enhancing efficiency. However, challenges such as resistance to change, resource limitations, and training issues must be addressed to fully realize the benefits of these techniques. The study underscores the importance of tailoring project management practices to the unique context of each manufacturing operation while continuously adapting to evolving challenges and opportunities.

## 5.3 Conclusion

The study provides a comprehensive evaluation of the critical factors influencing production efficiency, the impact of project management techniques, and the sustainability of efficiency gains in manufacturing operations. Through an examination of common production inefficiencies, the effectiveness of project management techniques, and the long-term sustainability of improvements, several key insights emerge that offer valuable guidance for enhancing operational performance in the manufacturing sector.

Firstly, the study identifies four major inefficiencies affecting production: inadequate infrastructure and equipment, human resource challenges, supply chain disruptions, and technological limitations. Inadequate infrastructure and outdated equipment are primary barriers, leading to frequent production delays and increased costs. Human resource challenges, including insufficient training and management practices, further exacerbate inefficiencies by creating errors and delays. Supply chain disruptions and technological limitations also hinder production efficiency, as delays in raw material supply and difficulties in integrating new technologies limit operational capabilities. Addressing these inefficiencies requires targeted investments in infrastructure, workforce training, supply chain resilience, and technology upgrades to enhance overall production effectiveness.

The study highlights the varied impact of project management techniques on production cycle times. Techniques such as Lean and Six Sigma have shown the potential to significantly reduce cycle times, with notable improvements observed in many cases. However, the effectiveness of these techniques is not uniform across all organizations. The findings underscore that while project management practices can lead to substantial time savings and efficiency gains, their success depends on factors such as implementation quality, training, and stakeholder engagement. The variation in impact suggests that a one-size-fits-all approach may not be effective, and a tailored implementation strategy is essential for achieving optimal results.

As revealed by the study reveals that the long-term sustainability of efficiency improvements achieved through project management techniques is complex and requires ongoing effort. While initial gains from techniques like Lean and Six Sigma are often significant, maintaining these improvements over time is challenging. Barriers such as high implementation costs, inadequate training, and resistance to change can undermine long-term sustainability. The study emphasizes the importance of continuous training, robust monitoring systems, and strong leadership to reinforce project management principles and address these challenges. Organizations must remain proactive and adaptable to ensure that efficiency gains are preserved and built upon over time.

Also, the study identifies several best practices and customization strategies that are crucial for the successful application of project management techniques in manufacturing operations. Best practices such as continuous improvement, employee involvement, quality control, and visual management tools are essential for maintaining efficiency and effectiveness. Customization of techniques, particularly Lean and Six Sigma, to fit the specific needs of manufacturing contexts enhances their applicability and effectiveness. However, challenges related to resistance to change, resource limitations, and training issues must be addressed through strategic change management practices and adequate resource allocation.

The findings of the study provide valuable and actionable insights for improving production efficiency and effectiveness in the manufacturing sector. By addressing common inefficiencies, adopting and customizing project management techniques, and focusing on sustainability, organizations can achieve significant improvements in their operations. The study underscores the need for a strategic and adaptable approach to project management, highlighting that continuous effort, targeted investments, and effective management practices are essential for long-term success and operational excellence.

## 5.4 Recommendation

Based on the findings of the study, several recommendations can be made to enhance production efficiency and processing times in the manufacturing sector.

* **Invest in Modern Infrastructure and Equipment** The study uncovers that outdated infrastructure and equipment are major production inefficiencies, causing frequent breakdowns and delays. It is recommended that manufacturing firms invest in modern machinery and upgrade their infrastructure to improve operational efficiency. Updating equipment will reduce production halts and maintenance issues, leading to smoother and faster production processes. The investment in infrastructure will also support the implementation of advanced project management techniques, which are hindered by outdated systems. Modern infrastructure will contribute to overall cost savings and enhanced production capabilities, addressing the critical inefficiency highlighted by the study.
* **Enhance Human Resource Training and Management** Human resource challenges, including insufficient training and poor management, are significant inefficiencies identified in the study. To address this, it is recommended that firms develop comprehensive training programs tailored to job requirements and implement effective management practices. Enhanced training will improve workers' skills, reduce errors, and increase productivity. Effective management will foster a disciplined work environment and better alignment between employee capabilities and job demands. By focusing on human resource development, firms can mitigate inefficiencies and optimize the benefits of project management methodologies.
* **Strengthen Supply Chain Management** The study reveals that supply chain disruptions, such as delays in raw material supply and inconsistent delivery schedules, impact production efficiency. It is recommended that firms invest in robust supply chain management systems to improve the reliability and timeliness of material supply. Implementing advanced forecasting, inventory management, and supplier relationship management practices will help reduce production bottlenecks and downtime. Strengthening supply chain resilience will mitigate the impact of external disruptions, ensuring a more stable and efficient production process, which is crucial for maintaining overall operational effectiveness.
* **Invest in Technological Upgrades and Integration** Technological limitations were identified as a barrier to production efficiency in the study. Firms are advised to invest in the latest technologies and focus on integrating these technologies with existing systems. This includes adopting automation, data analytics, and digital tools that can enhance production capabilities and streamline processes. Investing in technology will help firms stay competitive, improve operational efficiency, and facilitate the successful implementation of project management techniques. Addressing technological limitations will support long-term operational improvements and enable firms to leverage advanced project management methodologies effectively.
* **Implement Comprehensive Change Management and Continuous Improvement** The study highlights that maintaining efficiency gains over time is challenging due to factors like resistance to change and inadequate training. It is recommended that firms adopt a comprehensive change management strategy that includes regular training, strong leadership, and continuous improvement practices. Establishing a culture of ongoing learning and adaptation will help sustain efficiency improvements and address barriers to successful project management implementation. Continuous improvement initiatives, combined with effective change management, will ensure that gains are preserved and built upon, leading to sustained operational excellence and productivity growth.

## 5.5 Contribution to Knowledge

This study makes a significant contribution to the knowledge ecosystem of project management in manufacturing by offering a detailed examination of how project management techniques impact production efficiency and processing times. It provides empirical evidence on the effectiveness of various methodologies, such as Lean and Six Sigma, in real-world manufacturing settings. By highlighting the varied success rates and effectiveness of these techniques, the study enriches the understanding of their practical applications and limitations, offering a nuanced perspective that can guide future research and practice in the field.

Furthermore, the study's exploration of best practices and customization strategies offers valuable insights into how project management techniques can be adapted to fit different manufacturing contexts. The findings emphasize the importance of tailoring these methodologies to specific operational needs and cultural contexts, thereby advancing the discourse on effective implementation. This contributes to a deeper understanding of the dynamic nature of project management practices and their adaptability, which is crucial for enhancing operational efficiency in diverse manufacturing environments.

Lastly, the study identifies key challenges in maintaining the sustainability of efficiency improvements achieved through project management techniques. By addressing barriers such as resistance to change, resource limitations, and difficulties in training, the research provides actionable recommendations for overcoming these obstacles. This aspect of the study adds to the body of knowledge by offering practical solutions and strategies for sustaining long-term improvements, thus supporting the ongoing development and refinement of project management practices in the manufacturing sector.

## 5.5 Limitations and Suggestions for Future Research

This study, while providing valuable insights, has several limitations that should be acknowledged. First, the sample size and geographical focus—primarily involving manufacturing companies—may limit the generalizability of the findings to other sectors. The results may not fully reflect the experiences of manufacturers in different industries or geographic locations, potentially affecting the applicability of the recommendations. Additionally, the reliance on self-reported data from interviews and surveys could introduce biases, as respondents may provide socially desirable answers or may not fully disclose challenges and limitations.

Future research could benefit from a broader and more diverse sample, encompassing various manufacturing sectors and regions. This approach would enhance the generalizability of the findings and provide a more comprehensive understanding of the effectiveness and customization of project management techniques across different contexts. Additionally, longitudinal studies could be conducted to assess the long-term impact and sustainability of project management practices, offering deeper insights into how these techniques perform over extended periods.

Another avenue for future research involves investigating the role of emerging technologies in enhancing the effectiveness of project management techniques. The study highlights technological limitations as a significant barrier, suggesting that further research should explore how advancements in technology—such as automation, artificial intelligence, and data analytics—can be integrated with project management practices to overcome current inefficiencies. Understanding how these technologies can support, and augment traditional methodologies could provide new strategies for improving production efficiency and processing times in manufacturing operations.

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