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

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

However, Achieng (2021) posited that despite advancements in technology and automation, the average production cycle time in manufacturing has not significantly decreased over the past decade, underscoring a critical area for improvement. This stagnation can be attributed to several factors, including inadequate implementation of advanced methodologies, resistance to change, and the complexity of integrating new processes into existing systems (Schemel, 2021). Also, the lack of efficiency is prevalent mainly because of the ineffective planning, untrimmed resource buying, and the worst approach to implementation, which raises the manufacturing cost and time cycle and as a result, the supply chain effectiveness (Khan et al., 2022).

A relevant example here is Toyota, which is famous for its Lean manufacturing strategy and that has made towering standards in the global market in terms of efficiency and effectiveness. Toyota Lean manufacturing is otherwise known as the Toyota Production System (TPS) which has for many years been exemplifying the manufacturing world’s efficiency standards. By and large, TPS is committed to the never-ending, relentless search and removal of waste, the improvement of product flow, and the creation of ever-increasing levels of 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.

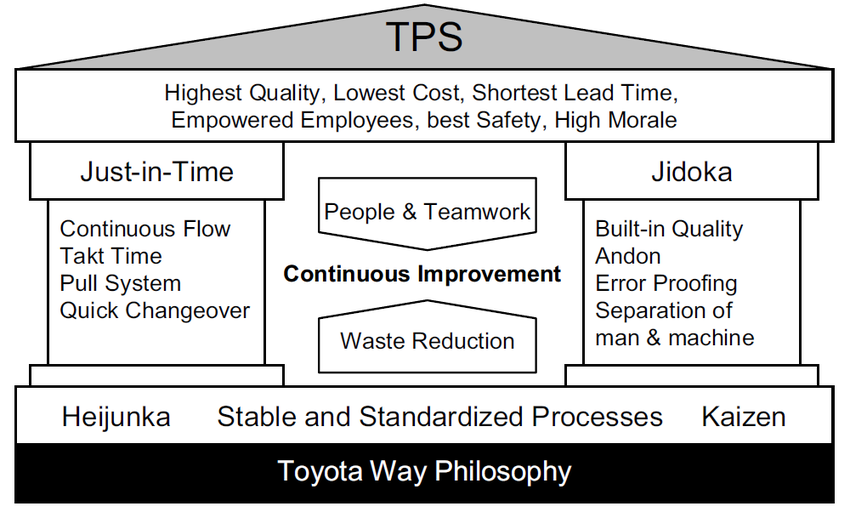


Fig 1: The core principle of the Toyota Production System (Herrmann et al, 2008)

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). When these concepts are applied alongside Lean manufacturing, the firms can realize efficiency, robustness and flexibility and sustain their stability and competitiveness in the event of large disturbances (Liker & Convis, 2012). Using the concepts of Agile project management it would have been easier for Toyota to respond to the ever-changing environment after the calamity. Both the concepts of scrum and Kanban are more dynamic, which makes them more effective since they incorporate flexibility and a constant iteration process and need for quick decision-making to adapt to new strategies that may be required. They have said that this was a particular strength since it would have been necessary to reduce the amount of time it takes before operations could be restarted (Schwaber & Sutherland, 2017).

The use of project management approaches in the manufacturing industry has gain a strategic and relevant aspect as industries aim at improving their operations, performance and product quality (Pozzi et al., 2023). Project management gives a planned framework through which planning, implementation and directing of production processes can be achieved. Proper application of these tools in project management enables provision of solutions in line with time and cost factors; something that is critical in provision of solutions to issues of risk and proper use of resources as postulated by Hindarto, 2023). Lean Manufacturing, Six Sigma, Agile, and Critical Path Method (CPM) are some of the project management techniques that have shown the possibility of increasing efficiency and decreasing the time taken to complete manufacturing (Stern, 2020).

**1.1 Problem Statement**

In recent years, the manufacturing industry has experienced severe hurdles in trying to minimize processing and manufacturing lead time. Even today some manufacturers must face several challenges and difficulties in various fields, which unnecessarily extend their production cycle and harm their competitiveness and profitability (Koren, 2010). This inefficiency is due to lack of efficient Project Management, still for effective project management in a specific field the field specific techniques are not fully adopted which are utilized in other fields like software development and services (Kerzner, 2013). For example, the car manufacturing industry, especially within the United States has continuously faced high pressure especially due to competition from other countries and increasing compliance standards. These pressures are aggravated by the fact that hunger and fullness schedules are not always well-coordinated with the business cycles (Womack et al., 2007). This incoherence puts a huge financial pressure on manufacturers and creates the need for a significantly more adaptive and flexible system of production management (Cusumano, 2010).

Traditional production strategies mostly emphasize on its throughput and compliance to industry set codes but largely lack policy on reduction in lead times and improvement on productivity. Consequently, the costs rise the amount of time required to bring a product to the market, and the extent to which manufacturers can adapt flexibly to market changes all elevate (Monden, 2011). The matters described above, both issues that the project managers face and the challenges that the worldwide manufacturing companies encounter, are solvable by the implementation of tailored manufacturing project management strategies.

The project management techniques like Agile, Lean and Six Sigma, for instance, have been proven to work in other industries creating efficiency, quality and eliminating waste (George et al. , 2005). However, their use has not widespread among the manufacturing industries in their usage. By applying these techniques, it is possible to improve production flow, eliminate delays, and optimize the consumption of production sources that can lead to substantial decrease in production and processing time (Antony, 2006).

The problem that remains then is that inefficiency in the manufacturing sector especially the time taken to produce and process goods has remained high, in this case due to poor Project Management practices. This inefficiency does not only affect operational performance of manufacturers but also their competitiveness within the world market (Flynn et al., 1995). However, it is apparent that there is a need for a collaborative and extensive study to seek out how project management best practices may be incorporated and implemented for the manufacturing industry to resolve these issues (Kerzner, 2013).

This study aims to fill the gap by investigating the potential of project management methodologies in minimizing the time taken in production and processing industries. To achieve these goals, the study aims at offering actionable solutions to the problem under analysis through outlining a set of best practices and the way to apply them into practice, which will contribute to manufacturers improved operational performance and competitiveness (Cusumano, 2010).

**1.2 Study Purpose**

The purpose of this research study is to critically explore the concept of how use of project management can enhance considerable decrease in production and processing durations in manufacturing industries. Nonetheless, even after implementation of efficient technologies and applying numerous efficiency models in the manufacturing industry, there are still outstanding manufacturing inefficiencies that have a negative impact on effective performance. It is our hope that this research seeks to establish the major root causes of these inefficiencies and measures the extent to which the application of project management methods can help organizational achieve its goals.

Manufacturing has for centuries played a significant role in the development of any economy; however, it is not immune to some of the common vices including poor resource management, faulty planning and poor implementation strategies. These are some of the scenarios that lead to long cycles of production, high costs of operations, and, therefore, low levels of competitiveness internationally. Current efficiency frameworks such as the Lean Manufacturing or Six Sigma have given significant benefits; nonetheless, they have limited utility when it comes to dealing with innovative, unpredictable challenges. These will be limitations that will be discussed in this study and the following sub-section will look at how project management methodologies can serve to address these inadequacies of the above traditional models.

Project management techniques include Agile, Critical Path Method (CPM) , and Earned Value Management (EVM) tools, all of which are different methodologies in the general aspect of advancing planning, execution, and control of manufacturing processes. This research will assess the efficiencies of these pedagogy in supply chain management, flexibility and response to interruptions. As the result of critical analysis of case studies of manufacturing firms that have successfully implemented these techniques, the study will identify key lessons and major success factors that can be applied across the manufacturing industry.

Additionally, the study will address the barriers about the challenges to the application of project management methodologies in the manufacturing industry. Lack of acceptance to change, organization culture, and the difficulty of implementing new processes into firm’s systems are other potential barriers to be met consciously. In that way, by conducting the critical evaluation of those barriers, the study will provide practical suggestions that might be helpful for manufacturing firms that strive to improve their operations and apply effective project management.

Lastly, this study will assess the long-term sustainability improvements linked to project management methods as well. Better improvements will be made in understanding whether such enhancements can be sustained in the longer term and what this means for the broad ability of production structures to respond to further adversity. As such, this study will also seek to offer important insights to the area of manufacturing by offering a critical and extensive understanding of the topic in question and present a competitive strategy guide for any organization that seeks to employ project management methodologies to optimize their time for production and processing activities.

**1.3 Study Aim, Research Objectives and Research Questions**

The aim of this research is to examine how project management practices can be also utilized to minimize production and processing time in manufacturing industry for improved effectiveness and competitiveness. Consequently, the objectives of the study are.

**1.3.1 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**

Manufacturing is a core component of growth, technological advancement and employment in countries across the world. However, it continues to experience several problems particularly one in relation to poor production and processes. The by-products of such inefficiencies can be increased costs that are reflected in the overall product price, decreased competitive advantage, and lower profitability. This is because the use of project management techniques is a potential way of tackling these challenges through presenting coherent paradigms on planning, implementation and monitoring. To this end, the prior studies pertinent to the inefficiencies in production process across the manufacturing industries and the impact and benefits of various project management methodologies have been discussed in this chapter. They cover theories and models for instance Lean Manufacturing, Six Sigma, Agile and Critical Path Method (CPM) and their effectiveness on cutting down production times. In addition, the review seeks to review some of the manufacturing firms that adopted these techniques and evaluate their efficiency and prove techniques that make the implementation effective and those that lead to inefficiency. This chapter endeavours to offer a synthesis of the existing literature in utilizing project management practices in the improvement of efficiency and productivity in the manufacturing process. I propose to derive a framework from this literature review that will be used to inform the successful applicability of project management methodologies in the manufacturing segment.

**2.2 Production Inefficiencies in The Manufacturing Sector**

The manufacturing sector, being a crucial pillar in the global economic growth of the globe, has a lot of challenges that hinder its performance. This section provides a critical review of the existing literature on production inefficiencies in the manufacturing industry about resource use, processes improvement and application of innovative methodologies. It provides the overview of the limitation and, suggest the possible avenue for further research.

Resource management is one of the critical determinants of manufacturing efficiency, but numerous studies highlight accounts of persistent challenges in this sphere. The study conducted by Khan et al., (2022) also shows that misallocation results in bottlenecks, low-capacity utilization and high operations cost. For example, one of the common themes is reliance on a set of manual practices because organizations have not invested in technology and automation support (Khan et al., 2022). This is observed especially with small scale manufacturing firms, where most of these firms rely on manual labour hence experiencing high labour cost and low productivity. This over-reliance results to high error rates, non-uniformity in product quality, and cost issues of scale, and competitiveness in the international market. As a result, these firms experience substantial operation challenges that might be eliminated by strategic purchase of automation technologies (Kusiak, 2018). Otherwise, they stick at the lower level, losing to counterparts with automated elements integrated into them. Additionally, lack of proper training and development of the workforce leads to an ineffective deployment of advance machinery and technologies and thereby serves to worsen the inefficiencies (Kumar & Parashar, 2015).

There is no factor that emphasizes the need of enhancing the manufacturing processes more than the temporal and financial parameters associated with the process. Lean Manufacturing and Six Sigma are two significant approaches accepted and implemented all over the world concerning improvement. As pointed out by Herrmann et al., (2008), although Lean production has good results on the reduction of wastes, it poorly describes variability and complexity issues in production. Likewise, Six Sigma extends beyond the prevention of defects yet is not as adaptable to change as the market may provide (Antony, 2004). These methodologies demand enormous cultural and organizational transformations that are usually resisted; this adds a layer of challenge in the implementation (Henderson & Evans, 2000)

Various advanced technologies like IoT, AI, and Robotics have been proven a potential solution to overcome the inefficiencies. Although the transformation towards smart manufacturing from the conventional manufacturing systems is facing some challenges. As posited by Pozzi et al. (2023), several organizations have not been able to adopt these technologies because they are expensive, and most of them are not able to find competent personnel to implement them. Further, in the current literature, there is a concern about integration of new technologies, with existing systems, which may in some cases lead to expansive down time and added layers of complexity to managing production operations (Kusiak, 2018).

The practical examples and case studies of other companies’ experience are informative and give an understanding of how one can eliminate production inefficiencies in practice. However, Toyota’s Lean manufacturing system, as has been observed, has not been an unblemished success story and the 2011 Tohoku earthquake has shown the disadvantage of having a just-in-time inventory system (Norio et al., 2013). This case also brings out the fact that contingency management or risk management, which are crucial aspects in managing a business, are usually underestimated in efficiency driven approaches. Likewise, other works pointing at other manufacturing firms acknowledge the need for optimizing efficiency as well as preparedness for external disturbances (Schemel, 2021).

Numerous literatures continually acknowledge the existence of different hurdles towards the successful execution of efficiency-improving approaches. Delay is also one of the major impediments caused due to unavailability of proper management support and lack of appropriate organizational culture (Achieng, 2021). Further, the coordination of change in new processes and technologies with the existing spatial organization of work increases the risk of disruption and decreased immediate performance (Hindarto, 2023). Such barriers need to be addressed cooperatively by making strategic plans that would involve engagement of all the stakeholders besides constantly training and developing the employees.

**2.1 Lean Manufacturing**

Lean Manufacturing, which is a process, undertaken with the help of the principles of Toyota Production System (TPS) is a popular method among manufacturing firm as it is aimed at improving the efficiency of production processes and reducing waste (Pawlik et al., 2021). The core principle of Lean Manufacturing encompasses continuous process, reduction of waste and improvement by focusing on creating value for customers by making the manufacturing processes more efficient (Bashar & Hasin, 2019). Being centered on minimization of non-essential actions and improvement of production processes, Lean Manufacturing seeks to increase efficiency, minimize expenses, and advance general efficiency (Kumar et al., 2022). Leksic et al., (2020) define Lean Manufacturing as approaching production from two angles, namely waste minimization, and streamlining of processes to affect production timelines. When people are engaged in good practice to seek value and eliminate wastes, lean principles can lead to shortening of cycle time and increase Through put.

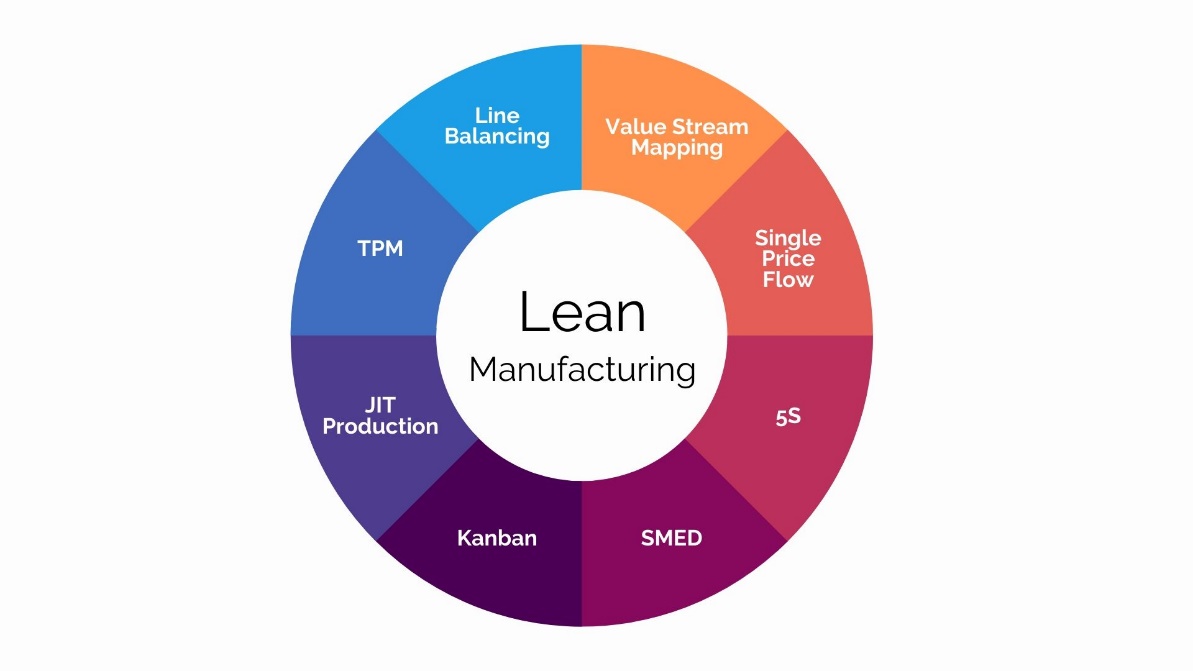


Fig 2: Lean Manufacturing

Techniques like the value streaming mapping will be very useful in establishing the areas of inefficiencies while tool like 5S and Kanban will considerably enhance the flow of work and inventory management, thus drastically reducing the time taken in production (Wang et al., 2024). Lean manufacturing also involves employees and establishes methods of structured problem-solving aiming at improving production and quality (Harnandez-Matias et al., 2020). Not only does this strategy reduce the cycle time of product creation but also improves organizational productivity thus reducing cost and satisfying customer needs. The lean construction concepts enable the manufacturers to commence improvements to adapt to the markets and technologies constantly (Javaid et al., 2022).

Various research works have demonstrated the importance of Lean Manufacturing in different organisations. Scholarly Studies reveal that Lean Manufacturing enhances Costs reduction, enhances quality and productivity among manufacturing companies that implement Lean manufacturing. Further, Lean manufacturing has been noted to extend its benefits when combined with other frames of reference including Agile manufacturing to improve the overall operational and financial efficient (Romero et al., 2019). This integration again brings out the fact that different manufacturing practices are not isolated practices, but they complement one another and may present some potential gains once integrated. Another important component of Lean Manufacturing is of the focus on waste as a component of the work process, and its eradication. Such a systematic approach towards waste minimization is critical to creating value, specifically to deliver value to customers (Ramadas & Satish, 2021). Lean manufacturing also highlights on the constant elimination of waste to enhance the operational strategies within production processes (Romero et al., 2019). Maximizing and optimizing value creating activities and minimizing the non-value creating activities help companies to increase competitiveness and sustain their position in the market (Elnadi & Shehab, 2021).

However, Lean Manufacturing is not only a work on the shop floor or some limited manufacturing field but is applicable to many industries apart from manufacturing sector alone. Starting from the basic metal industries to the aerospace industries, the Lean manufacturing techniques have been successfully implemented to enhance the organizational effectiveness and achieve the organizational performance standards (Hines et al., 2004). It is for this reason that Lean Manufacturing has been able to show that is serves as an effective organisational tool to achieving process improvements in a range of settings.

Analysing the situation of small and medium-scale enterprises (SMEs), one must mention potential problems of Lean Manufacturing in terms of employees’ constraints and opposition to change. Alack and understanding of these barriers are therefore important for appreciable improvement in Lean Manufacturing Implementation in SMEs (Ramadas & Satish, 2018). Thus, establishing an organizational culture that emphasises Lean methodologies is critical when it comes to the efficient application of Lean Manufacturing principles as well as attaining continuous enhancements in the business’s operational efficiency (Aripin et al., 2023). Through creating consciousness and empowering the employees, the organizations can eliminate barriers which prevent Lean Manufacturing and enhance the success of the implemented undertakings. Also, Lean Manufacturing is not a theory formulated and can be applied once and for all; rather, it is a concept that is expanding over time in relation to fluctuations in industries and technologies. There is a need to merge Lean Manufacturing with the growing trends in manufacturing that will enable the enhancement of manufacturing processes this include industry 4. 0 and cyber-physical systems opens possibilities for waste recognition and reduction in digital manufacturing environment (Romero et al. , 2019). These technologies have the potential of improving on the Lean Manufacturing configurations and improving on firm production systems.

**2.2 Agile Project Management**

Agile project management is an approach that focuses on flexibility and responsiveness in day-to-day project implementation by increasing cooperation of stakeholders (Zasa et al., 2021). The goal of this approach is to design and frame different project development processes in a way that minimises the risks of huge screw-ups, as the notion of iterative development means that the various phases of the project are built around ongoing feedback and subsequent modifications depending on the circumstances that will unfailingly occur during the project’s lifecycle (Mergel et al., 2021). Due to the division of major activities into smaller sub-activities, Agile project management allows for the providing of incremental value to the stakeholders in terms of the project’s progress (Ebirim et al., 2024).

Flexible planning and improvement are facilitated by agile methodologies which are so critically important for the modern world where the market conditions and new technologies constantly evolve. Agile developed from the idea of iteration enables manufacturers to respond quickly to change and apply corrections in real-time minimizing time wastage and improving the effectiveness of effectiveness. This is especially handy when it comes to a manufacturing setting that could easily be bogged down by delays and any form of inefficiency. As stated by Amajuoyi et al., (2024), since work is not divided into large sections but into smaller iterations called Sprints, Agile allows for regular or more frequent reflection and enhancement of paradigms in the process of working. Such a continuous feedback loop also centralises the supply chain and enhances the quality and speed with which the production companies can satisfy the customer’s needs. Therefore, the implementation of Agile methodologies to the manufacturing operations indicates a competitive edge in maintaining competitiveness and superior operations (Varl et al., 2020).

Another advantage peculiar to the Agile approach to project management is a focus on creativity in the teams formed. Several studies have established that Agile processes create appropriate contexts for creativity through collaboration to work when required and through focusing on customer value (Olszewski, 2023). Furthermore, Agile project management has been discovered to advocate for innovation within several sectors like the energy-efficient HVAC systems to promote iterative development and faster adaptation to the changing the scope of a project (Ebirim et al., 2024). Although embracing the Agile model has its advantages, it has some drawbacks – primarily when applying Agile at a large scale, which affects the overall scale of the enterprise and requires changes in the project management methods as well as cooperation among team members (Sońta-Drączkowska, 2024). There has been research done on the position of the project manager in Agile software particular teams primarily for the purpose of clearing any ambiguities and questions that may surround the position of project managers in Agile projects (Gandomani et al., 2020). This means that project managers must embrace the agility of agile method where planning and implementation differs from the regular project management.

Risk management is one of the other key Agile project management components. It is, however, important to know that Agile methods have their weaknesses, including the flexibility that comes with them which can lead to things as scope growth, time screw up and budget problems (Elkhatib et al., 2022). Risk management in Agile projects requires the identification and prevention of risks in executing the projects to enhance successful completion of the project to the satisfaction of the customers (Thom-Manuel, 2022). Therefore, when Agile software development projects incorporate risk management activities, then uncertainties can be managed, hence enhancing the projects. From the literature and empirical analysis, it can be realized that changing from conventional project management solutions to Agile methods involve some amount of strategic evaluation. Organisations embarking on Agile project management must ensure the following, that is, stakeholders, communication, and adaptability to support Agile in an organisation (Pinto, 2023). Furthermore, the use of the Agile methods can complement the traditional project management methodologies such as PMBOK and thus improve on project management practices (Silva, 2023).

There is a clear recognition of the several parts played by middle managers within the concept of project governance especially in Agile software development projects (Uwadi et al. , 2022). They support project governance for purpose of ensuring understanding with organizational objectives, facilitate communication among project team and deal with any issues that are likely to emerge when implementing the project. Moreover, Agile relates mostly to the project management tasks that allow teams to be adaptive and respond to new circumstances effectively as well as providing an iterative approach to work (Miller, 2019). In conclusion, it can be said that the popularity of the Agile project management approaches has gradually increased in diverse industries because it Focuses on collaboration and flexibility, which involves iterative cycles of development. With help of Agile paradigms, it is possible to increase innovation, shift organisational culture and better manage risks in the organisational projects as well as engage stakeholders. However, Agile project management can only be implemented when there is a change of attitude, and practices as well as the promotion of continuous improvement that can address the requirements of change in the project and the customers.

**2.3 Six Sigma**

Six Sigma makes use of statistical techniques to measure and reduce the variability of the process and hence the number of defects, thus minimizing time consumption (Duc & Thu, 2022). This is a process management technique that seeks to reduce variations and targets to be closer to the perfection though acknowledges that it is impossible, and this brings about an enhancement of the productivity of the production systems and the quality of the products. DMAIC which is the key methodology used in implementing the six sigma involves the following steps: Define, Measure, Analyze, Improve, and Control used to eliminate inefficiencies and eliminate causes of defects (Nandakumar et al., 2020). This structured approach of flow minimises variations and therefore, increases reliability and ultimately predictability of production outcomes. It makes not only the quality of production improved by decreasing variability and defects, but big timesaving when apply Six Sigma. Six Sigma in manufacturing leads to increase customer satisfaction, cost reduction and business edge since its execution is serve as advantage (Madhani, 2020). The focus on using data for decision making and the concepts of the never-ending cycle of improvement enhances good organizational performance and operation.

An important benefit of six sigma system is the application of different statistical tools to define the problem and prove changes for better are efficient and effective (Feng & Manuel, 2008). This kind of operating approach is highly valuable in health care organization setting that requires near perfection and high quality. Next, Utomo (2020) conducted a literature review on Six Sigma’s application in service industries while touching upon scholarly works on how this methodology can be applied in service industries. This adaptation of Six Sigma to service industries and health care expands the functionality of the program and its success in these areas. Therefore, the study focuses on the application of Six Sigma minimisation of errors of healthcare payer firms providing a valid proposition for Six Sigma in managing certain aspects of the health care industry (M & Kunnath, 2019).

Prior research has supported the use of Six Sigma within many manufacturing fields including ceramic, paper, gems and jewellery, cement, furniture and forging industries (Patel & Desai ., 2018). The methodology being explored in this paper has been applied to certain problem areas which include but are not limited to the following: lowering failure rates in the testing of high voltage insulators (Desai & Shaikh, 2018), enhancing grinding processes (Noori & Latifi, 2018), and more importantly averting industrial mishaps (Ray, Teeboon, & Khoo, 2011). Also, the Six Sigma has helped in the reduction of oil leakage in heavy duty transformers Neeru et al., (2023) and has improved the efficiency of training and development in the pharma sector Chakraborty & Pant, (2024). Another tool that has also recently been adopted in the manufacturing field is Lean Six Sigma, a blended model of Lean Manufacturing and Six Sigma, which has also been known for the initiation of suitable measures for continuous improvement and enhanced environmental performance (Huang et al., 2023). Research has found that the application of Lean Six Sigma techniques, use of data and facts, and organizational culture improve sustainability to gain competitiveness in the organization (Huang et al., 2023). Besides, incorporating Lean Manufacturing and Six Sigma proved successful in its application for organizations’ continuous improvement in industries and services (Silva, Oliveira & Magalhães 2023).

The best practice of Six Sigma in manufacturing industry have been established as leadership and strategy, market and customer, assessment and commitment, and project management by Yi‐zhong et al. , (2008). These critical success factors have a very important role in the successful application of Six Sigma methodologies in manufacturing organizations. Further, Six Sigma has been linked to the reduction of defect rates, rising sigma levels and performance enhancement in several industries inclusive of the pharmaceutical industry (Alkunsol et al. , 2019).

**2.4 Critical Path Method (CPM)**

CPM also known as Critical Path Method provides an organised system of planning and identifying the task in the order that brings out the sequence of tasks that must be accomplished on time for the entire project to be completed as planned (Suryono & Hasbullah, 2020). As it controls activities and their relationships and prioritises tasks on core business, it reduces potential holds-ups and use of resources (Taghipour et al., 2020). This method ensures that resources are allocated where they are most needed, there are no bottle necks hence cutting down cycle time. CPM acquires specific task sequences and time frames and supports the reorganization of operations among team members, which enables more efficient work (Khandekar, 2020). The focus placed on critical tasks allows to address possible delays and keep project ongoing and complete it within the least amount of time possible.

Critical Path Method (CPM) is a deterministic scheduling approaches prominently employed across different industries but primarily in the project construction industries (Mak & Mbz, 2023). In CPM, determination of the crucial path is helpful in outlining the sequence of activities that make it impossible for the project to be of shorter span as per the intended plan (Pankaj, Kumar & Agarwal, 2020). Basically, critical activities, the critical path indicates the possibilities toward project compression and potential risks (Ali, Tjendani & Witjaksana, 2024). This CPM helps to determine the duration of the project, to evaluate the options of its scheduling, and to maximize the project’s timelines (Wulandari, Dachyar & Farizal, 2018). Being a key instrument in managing planned projects, schedule is used for its planning and control, as well as for checking resources allocation and flows regulation (Olivieri, Seppänen & Denis Granja, 2018).

Furthermore, CPM is usually applied hand in hand with Project Evaluation Review Technique to calculate the success probability of the project as well as to identify risky activities (Hana & Tjendani, 2022). CPM and PERT help analyse project timelines and the more critical activities that can be used to identify effective measures towards accelerating a plan (Hana & Tjendani, 2022). Also, CPM has been employed in the construction project scheduling right from its formulation in the early period of 1950s and is still relevant and highly effective tool for time management and scheduling of construction projects (Ökmen, Bosch-Rekveldt & Bakker, 2022). However, CPM has strong scheduling activity since criticisms have made towards the fact that the approach is deterministic in the sense that it does not incorporate schedule uncertainties experienced in projects (Ock & Han., 2010). However, this critique has not hindered CPM from being one of the most used and useful tools in project management because of its provision of an organized framework for managing project plans and control (Simion et al., 2019).

**Common production inefficiencies in the manufacturing sector**

Some of the common sources of production inefficiencies that can be tolerated in the manufacturing sector are some of the challenges that the industry experience. These challenges include areas of knowledge concerning the workforce education (Daum et al., 2024), the complexity of manufacturing systems (Huah, Mahmood & Rahman, 2018), the product mix and customisation (Andersen et al., 2018) and flexibility in the production process (Wan et al., 2021). Also, some of the issues that limit ultra-precision manufacturing include poor process control and material handling (Adeleke, 2024), inflexibility of conventional manufacturing technologies to support mass production (Lee et al., 2020) and comparatively low production rates of additive manufacturing as compared to conventional manufacturing technologies (Coatanéa et al., 2021).

In addition, the industry faces problems associated with the implementation of new technologies, for example, 3D printing technologies (Shahrubudin et al., 2020), the constant search for new sophisticated products and processes as a means of meeting the needs and wants of the consumer (Helman, 2022), and the influence of globalisation on manufacturing environments (Ariafar et al., 2012). Besides, other factors like high operational complexity that exists in Engineer-To-Order operations (Strandhagen et al., 2019), regulatory hurdles in cell therapies manufacturing (Hourd, 2014), and challenges to digitalization for manufacturing firms according to Ahmad et al., (2022) also contribute to the inefficiencies that manufacturers experience.

To overcome such inefficiencies, manufacturers need to pay particular attention to improvement of the processes for cell therapy manufacturing (Fritsche et al., 2020) and using of reinforcement learning for sustainable and lean production (Paraschos, 2024) and defining strategies for success in local manufacturing environment (Koren et al., 2017). Besides, the use of technologies such as reconfigurable manufacturing systems, artificial intelligence based customized manufacturing factories, and digital representation of the manufacturing processes support improves efficiency in addressing manufacturing issues.

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

The production processes in the manufacturing industry have been improved by use of project management techniques since they are the most significant determinant of production cycle time. Efficient project management will result into efficient processes that helps in management of resources and production hence shortening cycle times. Companies in manufacturing experience several factors that affect the duration of the production cycle time, and PM addresses the factors. Decision making is another area that is not left out by project management especially when it comes to the planning and scheduling of manufacturing processes. Project planning is vital in determining the most appropriate order of activities, appropriate use of resources and likely delays hindrances which must be prevented Irfan et al. (2021). Project managers can divide projects into workable tasks, identify the timeline and the activities that have a direct bearing on cycle time by using tools like the WBS matrix and CPM as well as PERT techniques (Sutrisna et al., 2018; Bagshaw, 2021).

Also, Project Management is an essential element in managing resources within manufacturing operations since great resources are spending on projects. Time factors are critical elements of production cycle time, and therefore it is crucial to direct materials, equipment’s and manpower resources appropriately. There are techniques and tools which project managers can use to facilitate better inventory management, demand forecasting, and production planning, so the resources are used to the optimum and the production processes don’t get hindered (Yeshwanth & Bhavana, 2022; Dey, 2002). Moreover, talent management practices and transformational leadership can also build up the performance of the employees and increase innovative work behaviour, which would also aid in the improvement of the production cycle time (Sayyam et al. , 2020). The following is a cross between Quality Management Practices and Project Management in the manufacturing sector; Quality practices improve product quality and reflect on the way the product is produced. Zwikael & Globerson (2007) have established that the implementation of TQM is associated with the ability to achieve ongoing process enhancement, eradication of wastes as well as improved organizational effectiveness. When manufacturers factor in quality management into their project management systems, they are likely to realize enhanced productivity and shorter cycle time.

Also, the implementation of digital transformation to address project and capture management brings sustainable growth in the manufacturing SMEs based on the real-time monitoring, data-driven, and effective collaboration from the team members (Awonuga, 2024). Big data integration can also add great value in terms of giving insights, risk identification and optimal results for the project performance (Mangla et al., 2020). Therefore, it can be noted that the application of project management techniques significantly influences the times for the production cycle in the manufacturing firms. Using other tools and strategies like planning for projects, managing resources, practicing quality and embracing digital technologies, there will be a proven way on how the manufacturers can cut on their time when conducting production cycles. Project management not only improves operational performance, but also avails organizational objectives and competitiveness to the volatile operating manufacturing environment.

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

The adoption and the effectiveness of the project management practices in manufacturing also depends on several key factors that have important impact towards project success. These factors cover such areas as leadership competencies, project planning and control, risk management, human factors and external environment. If the above factors are well understood and dealt with, the manufacturing companies can work toward developing good project management competencies and therefore improve their total organizational effectiveness. Of the many factors within the manufacturing organization that are significant in the application of project management practices, the leadership competencies of project managers are found to be core. The huge volumes of research have indicated that inner confidence, self-belief, and self- leadership skills are central in enhancing the delivery of projects among the project managers Geoghegan & Dulewicz (2008). Thus, strong leadership is instrumental to enhancing the appeal and motivation of the teams, controlling the pace of the projects and their efficient problem solving which are some of the key factors likely to lead to the success of the projects.

Another key component is also the project planning and control in which project management practices in manufacturing are accomplished. In relation to the existing literature, it has been found that other factors like project related factors, project procedures, project management actions and human factors are influential to the success of project planning and control processes (Li et al., 2018). Manufacturing companies can improve the project planning and control by setting up clear project objectives, describing project activities and completing powerful project management activities. Furthermore, there is evidence that risk management practices incorporated into project management have a potential of greatly enhancing project success in the manufacturing sector. Risk management especially in manufacturing projects including but not limited to the development of new model car calls can have a positive impact in the level of project management performance and consequently can contribute to the success of the projects (Fernando et al., 2018). Thus, managing the risks reduce the adversities that may come along the way, enable efficient use of resources as well as improves the project outcomes.

Other virtual aspects that are associated with people include communication, team integration, and stakeholders for the successful adoption of project management practices in manufacturing firms. Lack of job satisfaction, the competency of team with assigned projects, and communication channels are some of the issues that dictate the desirable organizational climate for project environment (Kendra & Taplin, 2004). Emphasizing human factors and enhancing project culture thus allows manufacturing firms to form sturdy project constituencies and create pertinent projects. Moreover, other external factors which include the market trends and changes, regulatory policies and standards that steer innovation and development affects the proper adoption of project management practices in manufacturing. Therefore, flexible project responses to the outside world, project plans that correspond with the market, and effective incorporation of new technologies will help achieve the goals set by the project in the context of a constantly evolving manufacturing environment (Pacagnella et al., 2019). It stresses the idea that through careful attention to outside influences and constant adaptation to marketplace conditions, improvement to an organization’s project management can be achieved and thus the optimum method of ensuring positive results on the projects.

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

It is important to note that only long-term concepts of efficiency improvement through project management techniques in the manufacturing sector will enable continuous success, competitiveness and growth. On the same note, He’s points into practices and strategies in project management that manufacturing firms can undertake to achieve efficiency in the short run while, at the same time, attaining long-term stability. Immersive factors that affect sustainability of efficiency gains in manufacturing include leadership engagement, CIM culture, technology applications and seven key triggers for change. Two; Organization commitment from leadership is central to the sustenance of efficiency gains realized from the use of project management tools and practices. Institutional support is important for Change management and even for sustaining improvement initiatives and gains over time Roy Fitriadi (2023). Managers must promote the efficiency drives as well as support the various projects, monitor resource intake, and offer leadership to the projects’ teams to ensure that the gains would be constant in the long run.

Culture of continuous improvement is one of the key drivers that can help to sustain the improvements on efficiency gains in manufacturing. By supporting the culture that is built on innovation, learning, and adaptability, it allows the companies to always see where improvements and developments can be made, strategies and best practices can be applied, and overall, provide the opportunity and means to work on increasing organizational performance by 5 percent annually (Awonuga, 2024). Engagement of the employee, training to new methodologies and lastly, recognition of the efforts to improve such a culture is crucial for the organization. The application of IADT has a critical contribution to the reinvention and continuation of enhancement of manufacturing efficiency. The integration of automation, data analytics and artificial intelligence would by facilitate automation of different procedures, organizational efficiency and effectiveness of the decision-making process (RONO, 2019). By adopting the digital technologies any manufacturing organization is of capability to enhance its operational performance, increasing the productivity, flexibility and capacity to meet the market challenges to maintain the productivity gains in the manufacturing system.

Furthermore, flexibility is important for maintaining improvements in manufacturing efficiency in the light of dynamic market conditions. Adaptability to changes in the market needs and other disruptions that may occur within an industry is crucial for organizations to sustain their competitive presence and viability in the apparently increasing competitive environment (Tito & Sarker, 2020). Manufacturing organizations require flexibility in their operations, customer needs, and changes in the market environment and adapt to the changes and sustain manufacturing improvements. Also, risk management gets significant importance in manufacturing for the sustainability of efficiency improvement. Challenges and uncertainty, therefore, remain a key consideration differently by outlining risk factors, risk control plans, and performance measures by which companies could systematically overcome efficiency obstacles (Chen & Yang, 2021). Effective risk management being a key element in protecting solutions, maintaining business operations, and preserving the continual enhancement of solutions, it is a crucial point.

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

To understand this concept, it will be necessary to perform a critical evaluation of several existing empirical works. Although both assessments are different, it is possible to compare them in such a way that we derive lessons from various related areas of study and identify a research agenda to guide future studies. For example, Aimee & Nkechi (2022) present a detailed discussion of the trends regarding the management practices of project in relation to civil construction in Rwanda. Before that they stress on how elements of the Project Management Body of Knowledge (PMBOK) and Agile methodologies can help improve project performance. From their research they established that there are areas of efficiency for example, in the management of time resources that are enhanced when formal project management practices are put into use. While this study does point to some interesting trends, it’s important to note that this paper is confined to the field of the public sector exclusively; as a result, there are certain questions concerning applicability of these observations to the manufacturing industry.

On the other hand, Ala et al. (2012) came up with stochastic model that focuses on extending the production cycle time in metal processing industry. It is important in emphasising the significance of statistical and probabilistic tools in analysing as well as preventing delay in production lines. The model’s effectiveness in decreasing the cycle times also brings out the significance of evidence-based decision making as well as the constant process improvement, two foundations of both Lean and six sigma principles. Whereas this study is concerned with rather general project management practices as seen with Aimee & Nkechi (2022), Ala et al. (2012) offers a more instrumented view, underlining the necessity to apply particular tools and theories for manufacturing projects. In addition, Cuatrecasas-Arbós et al. (2015) are concerned with inventory management and manufacturing lead times. They also prove that a well-coordinated and efficiently set up monitoring and control system leading to a much less amount of production delays. Here some benefits of the implementation of the Just-In-Time and Kanban systems in the manufacturing industry include Flexible manufacturing methods are employed to reduce inventories, streamline their operations as well as minimizes lead times. According to the Lean manufacturing, this study will also argue that there are many wastes that ought to be eliminated to enhance the overall organizational performance. Yet, the study does not go further to explain the application of these systems with additional methodologies that are commonly used in project management including Agile or Six Sigma where efficiency improvement could be realized.

Durakovic et al. (2018) further takes the discussion to the enactment issues/movement and the trends related to Lean manufacturing. In their empirical studies, they reveal five categories of factors that hinder successful Lean strategies execution including change resistances and inadequate training. That way, organizations can improve on the application of Lean principles in increasing production efficiency. The lens therefore provides this study’s critical insight, which is that while technical solutions may be developed, they require accompanying cultural and organizational adjustments. This is in line with Panayiotou, Stergiou & Chronopoulos (2022) who adopted Lean Six Sigma toolsets to execute enhancement projects which led to positive results in both manufacturing speed and quality assurance. Their case study shows that integration of Lean and Six Sigma approaches offers a wider benefit as compared to using them separately.

In the same vein, Panayiotou, Stergiou & Panagiotou (2022) stress on low-cost, high-impact interventions in the SME settings. Hence, their research reveals that Lean Six Sigma can lead to large improvements within SMEs and these do not require extensive implementation efforts on a large scale like most large firms. This is quite pertinent to the SMEs in the manufacturing industries more so the ones that have a small financial capital to invest in the process improvement projects. The study therefore supports an approach that evaluates the specificities of these SMEs by identifying their specific barriers and opportunities thus expanding the use of Lean Six Sigma.

Following the analysis of Fernandez-Viagas & Framinan (2015), it is possible to distinguish two approaches to the trade-off between processing time and resources. The authors discuss on the controllable processing times in project as well as production management they have found out that there is a high potential of minimizing the processing times through effective utilization of resources. The main strength of this study is that it presents findings on specific levels of resource inputs and time savings for manufacturers to guide them in their attempts to maximise on the time aspect while minimizing on the input aspect. The results extend the work of Cuatrecasas-Arbós et al (2015) by underlining the value of managing resources in parallel with the processes. However, despite the huge efforts, these studies are characterized by certain drawbacks and disparities. For instance, Aimee & Nkechi, (2022) insists on such seemingly general features as strategic approaches to the management of structure and organization and administrative project, but Fernandez-Viagas & Framinan, in their work of 2015, stresses such detailed aspects as resource management and processing time. This is evident from the difference in the two approaches and confirms what has been revealed from the empirical studies; that there is need for contingent research work that not only embraces the overall strategic view of project management frameworks but also details out the resources and processes to be utilised.

However, few of the research studies investigate those methodologies’ long-term efficacy, or the enduring effects of their implementation. Most of the studies, like Ala et al., (2012) and Panayiotou, Stergiou, & Chronopoulos, (2022), only give a short-term outcome while they do not focus on the long-term maintenance of the achieved related enhancements. Future studies in the longitudinal framework might afford additional understanding of the prevailing durability and antecedents of these efficiency improvements. Last but not the least; Lean, Six Sigma and Agile methodologies have been researched separately but there is dearth of literature regarding their synergy. Research by Durakovic et al. (2018) and Panayiotou, Stergiou, & Panagiotou (2022) show that Lean Six Sigma can have positive effects, but the lack of extensive investigation about how different approaches can be applied to enhance process improvement. This is an indication that more research is possible in the future to establish the combination of different techniques of project management as there are positive signs from both.

**Conclusion**

In conclusion, the literature review in this paper highlights some of the compelling systemic inefficiencies pervading the manufacturing industry, including the resource management, process improvement, and the use of innovative approaches. It indicates that there are still many problems in managing supply chains such as improper distribution of resources, excessive reliance on paper-based systems and insufficient training of human capital. Several studies have also revealed that Lean Manufacturing and Six Sigma as two useful approaches in managing the inefficiencies, but both are not devoid of certain drawbacks. Lean Manufacturing is good in minimizing wastes but not very good on Variability while Six Sigma method is very good on the technicality part but might not capture market fluidity. Meanwhile, the application of modern technologies such as IoT, AI, and robotics has demonstrated considerable opportunities for increasing productivity; however, while adoption costs are rather high, and the problem of interfacing remains relevant. Future research should address the methods for integrating the advantages of different types of approaches and analyze the long-term outlook for efficiency improvements to offer a more extensive application to the issues within the sphere of manufacturing.

# **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. It is the main purpose of this research to examine how any changes to project management techniques can minimize the production cycle times and to determine crucial success factors for these techniques; to assess the long-term durability on identified efficiencies and to establish specific recommendations for different manufacturing contexts. Therefore, this section is proposing the subtopics which are as follows, Research Design, Data Collection, Sampling, Research Instruments, Data Analysis, and Ethical Considerations.

## **3.1 Research Design**

For this dissertation the mixed research design approach has been chosen as the best approach to employ both the quantitative and the qualitative research methods. This method is highly appropriate for this study as it enable for the broader and deeper analysis of the research problem. This design makes it possible to triangulate data collected through the two approaches used making the research study more valid and reliable according to Creswell & Tashakkori (2011). The qualitative data will complement the quantitative data since it helps to explain the why of a situation while the quantitative analysis will give evidence to the qualitative assertion. Thus, the present integrative approach is effective to provide balanced answer to the research questions that contain both ‘how’ and ‘why’ aspects of a given phenomenon. This approach is particularly suitable as it makes it possible to conduct an extensive study of the effects of implementing project management techniques in product manufacturing and processing time in the manufacturing industry. In this mixed method research the combination of quantitative and qualitative data has an additional benefit because it gives a better overview of the research problems than when using only quantitative or qualitative data (Creswell & Plano Clark, 2011).

**3.1.1 Qualitative Research**

The second part of the research is the qualitative part that will aim at identifying the environmental factors that affect the use of project management methodologies and how effective they are. Whereas qualitative research is very useful when it comes to studying abstractions such as organizational culture, leadership style, and stakeholders as they are all vital when managing projects (Denzin & Lincoln, 2018). For this research, the data type that will be collected will be in the form of qualitative data collected by conducting semi structured interviews with project managers, engineers among others in the manufacturing industry. These interviews will provide better understanding of the participants’ experience, difficulties and attitudes regarding the implementation and application of the project management.

To make comparisons and assessments the chosen approach will be thematic analysis which is a method of categorizing qualitative data into themes and patterns. This approach is justified by the fact that to understand or know what has contributed to or has been making difficult the success of project management initiatives, it will require a bracketing off as recommended by Braun and Clarke (2006). Also, there will be the analysis of case studies of manufacturing firms that have adopted the use of project management methodologies. In the research methodology, case studies provide exhaustive information on a given problem directly in its real-life setting; this happens because they are based on qualitative data (Yin, 2018). These case studies will only open resourceful real-life examples of best and poor practices that will expand my understanding of the research problem based on context.

**3.1.2 Quantitative Research**

The quantitative research will then be conducted in parallel with the utilization of quantitative data to statistically test the effects of employing different project management methodologies on the cycle time of production. Quantitative research is crucial in determining the strength or magnitude of the association between variables as well as in making conclusions concerning the whole population (Creswell, 2014). In this study, quantitative data will be gathered by development of structured questionnaires to be used in distributing among the project managers and other heads of operations in the manufacturing firms under study. Such surveys will aim at determining other factors like the application of, or shift of, project management techniques, as well as the perceived efficacy of such a technique.

The Quantitative data collected will be analysed statistically to make inferences and testing of the hypotheses. The relationship between the implementation of project management techniques and the reduction in production times will be analysed by regression analysis and correlation analysis. The application of quantitative analysis is explained by the fact that research hypotheses emerged from the analysis of the literature and qualitative data need quantitative validation or rejection. In addition, comprehensive numeric information about the given expectations will also be collected to corroborate the qualitative impressions received and obtain sound and relevant conclusions that would be quite accurate.

**3.1.3 Primary Research**

The technique of primary research is largely the foundational aspect of this study, since it involves the collection of primary data which is directly related to the research questions at hand. The conduct of primary research is informed by the fact that there might be certain information that might be relevant to manufacturing operations and which may not readily be available in literature. Therefore, this research focuses on the collection of primary data to fill research gaps observed in the literature review and provide new insights into the use of project management methodologies in manufacturing contexts with a view of establishing their facilitate and limitations. Saunders, Lewis & Thornhill (2019) have explained that primary research is highly useful in exploratory research situations where the context-specific information is needed. This method will get information in detail that may not be available from secondary sources since this research will survey, interview and use cases professionals in the field.

## **3.2 Data Collection**

The selection of data collection tools is therefore important to enable the realisation of the research objectives, as well as ensuring that collected data is credible and accurate. Due to the nature of this research, interviews and questionnaires will be used with the respondents to attain both qualitative and quantitative data to meet the objective of understanding the impact of project management techniques on production and processing time of the manufacturing firms.

### **3.2.1 Interviews**

**Type of Interview**: The qualitative data-gathering tool shall be the semi-structured interviews. It is for such reasons that the use of semi-structured interviews is particularly useful in conducting this research in that is avails a balance between tightly structured and open-ended questions as proposed by Bryman (2016). This method of interviewing makes it possible for the researcher to focus on several themes simultaneously and still be let by the participant to offer his or her own opinion and come up with other themes not predicted by the researcher.

**Design of the Interview**: The interview guide was deliberately structured to elicit information on several issues relating to the research questions, including: the problems and advantages of applying project management methods; the effects of these approaches on the cycle time of production; and the factors that can make or mar successful implementation. The interview questions are general and specific so that the participant’s experience and view on the measure can be elicited and explored thoroughly. Another important technique is writing open-ended questions since such questions involve respondents giving detailed unique answers based on the personal experience of the respondents (Kvale & Brinkmann, 2015).

**Delivery of the Interview**: The interviews will be conducted virtually through some couple of popular video conferencing tools like; Zoom conference and Microsoft Teams then chosen based on the availability and the willingness of respondents to use the selected tools. Yet flexibility and convenience may be gained through video conferencing especially when the participants are in different places (Opdenakker, 2006). Because 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. Each conducted interview will be conducted with the permission of the participants to be taped and a written consent will be sought from the participants to offer their views to be recorded.

**3.2.2 Questionnaires**

**Design of the Questionnaire**: Questionnaire was developed to elicit quantitative data that are in addition to the qualitative data that was obtained from the interviews. They were organized in a closed and open-ended format which enabled the collection of quantitative data as well as qualitative data which give more depth to the study. Most of the closed-ended questions are developed in the form of Likert scale where the respondents will state their level of agreement or disagreement with certain statements pertaining to the management practices of production cycle time.

**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 questions on the questionnaire were asked in such a way as to avoid ambiguity and to make the completion of the form easy. This was followed by a brief information about the subject of the research and the anonymity of the responses which was given to the participants. Questions were categorized into different areas of concern in relation to the research study including the nature of project management methodologies applied, the perceived effects on production time and some of the emerging difficulties. For each section, clear instructions were given and as mentioned before, the questions will not be confusing in any way, such that they will be stated simply and directly (Dillman, Smyth & Christian, 2014).

**Delivery of the Questionnaire**: The self-administered questionnaire was sent through email, WhatsApp or any other means of passing messages with an online link in Google Forms. The advantage of an online health survey is that it makes data collection easier as the researcher can cover more people and retrieving and managing the data is very easy. Respondents were allowed a certain limited amount of time to complete the questionnaire; follow-up reminders were also made to all the respondents. To improve response rate, the proposed questionnaire was made short, with total estimated time to complete it being 10-15 minutes, so as not to bore or exhaust the respondents.

## **Sampling**

**Quantitative Sample**

To make the study sample statistically valid with an aim of generalising the results, this study will select at least one hundred responding manufacturing firms. This number is arrived at to provide adequate data while at the same time being conscious of the time and resources required. To have samples of different types of manufacturing industries such as automobile, electronics, and food industries, stratified random sampling is to be used. Specifically, stratified sampling is relevant in the current context since it enables the researcher to guarantee that specific subpopulations in the target population are adequately captured into the sample to reduce on biased prejudiced sampling, thus increase the reliability of gathered data by embracing different points of view (Etikan, Musa, & Alkassim, 2016, p.12).

**Qualitative Sample**

Semi-structured interviews will be conducted with possible response rate of 5 with key participants – project managers and engineers and detailed case studies. Such sample size is used to achieve the study’s purpose of assessing the depth of the implementation processes and the associated challenges faced. In the case of the qualitative part of the study, purposive sampling will be employed which will enable the researcher to locate participants and cases that are most familiar with the use of project management tools. This is defensible and justified as this involved the use of Information-rich case method that can generate in-depth understanding out of the research questions as postulated by Palinkas et al., (2015).

## **3.3 Validity and Reliability**

To some extent, the reliability and validity of the research instruments should be guaranteed in ensuring that accurate results are arrived at in any empirical study. Validity is the accuracy of measurement of the concept in question while reliability is the stability of the measurements across time of the given concept (Morse, 2018). In the case of this dissertation which is on the application of project management techniques to minimize production /processing time of manufacturing firms hence enabling production upturn, validity and reliability always plays an important role to make meaningful findings that can be generalized .

**3.3.1 Validity**

Different types of validity must be considered: reliability, objectivity or internal validity, and construct validity and external validity. Content validity involves a verification that the entire content of the instrument is in touch with the construct under study. By so doing, the interview questions and the questionnaire items will be constructed from a synthesis of the literature on project management and production efficiency, to cover all the factors in the two concepts comprehensively (Hayashi et al., 2019). Some professionals involved in project management and manufacturing will be contacted for opinion on the research instruments to offer feedback on the questions and ensure that they exhaust all aspects of the research and that the questions set served the objectives of the study.

**Construct validity**: The science-oriented validity known as construct validity is more focused on whether the given instrument measures the theoretical constructs to which it is designed to measure. Whereas construct validity will be the assurance of the measuring instruments that the questions asked to reflect the theoretical definition of the variable construction, for instance, construct validity will incorporate by operationalizing the measures of project management practices and production time efficiency. Another factor that will help in construct validity is the use of scales and measures developed in previous studies, hence facilitating construction of the instruments in line with the best practice in research (Trochim & Donnelly, 2008).

**External validity** or generalizability of the results refer to the generalization of the study results to other populations. Although, this study is sectored and aims at the manufacturing sector, care will be taken to make the sample comprise of various sub-sectors in manufacturing. This will improve the extent of transferability of the outcomes in other manufacturing contexts (Leedy & Ormrod, 2019). Furthermore, the use of both qualitative and quantitative data, as well as the mixed method approach will increase the externality of the study since the researcher will get an understanding of the phenomena in their richness, and therefore, a high chance of generalizing the findings beyond the study context.

## **3.3.2 Reliability**

Reliability therefore can be described as the dependability of the measurement system. Reliability of the research instrument may be defined as the ability or capacity of a research instrument to yield the same results whenever it is applied under identical circumstances. In this study the following measures will be used to increase the reliability of the data collection instruments. Internal consistency reliability will be measured using the questionnaire within a pilot group in the study by giving it at two different points in time to cross check whether the obtained results show high correlation indicating stability over a given period. Therefore, if the observed correlation is high, then the measure of reliability of the instrument to produce consistent data can be established.

It will be essential to establish **Inter-rater reliability** especially when it comes to qualitative data that shall have been garnered from the interviews. This will be done by soon after selecting a sample of reports we will use several researchers to code that data and then compare the degree of consistency in coding. These differences shall be addressed and brought to consensus to make sure that the procedure of coding is consistent among the coders (Cohen et al., 2018). This step is important avoid as much subjectivity as possible in the analysing of results given that the study is qualitative in nature.

Internal consistency reliability which can be defined as the pooled correlation between items/ questions in a questionnaire assessing the same criteria will be estimated using Cronbach’s alpha. Moreover, the reliability has been determined to be high with Cronbach’s alpha coefficient of 0. I will use an alpha coefficient of 0.7 or above which will be acceptable meaning that the items in the scale are consistent and are measures for the same variable (Field, 2018). This statistical measure is going to be used so that the various items of Likert scale questions included in this questionnaire are going to contribute in a consistent manner towards the construct under consideration.

## **Data Analysis**

**Quantitative Analysis**

Qualitative data that will be collected through questionnaires will be scaled data and will therefore be analysed using statistical methods such as regression analysis, ANOVA AND correlation analysis. Regression analysis will be employed to determine the correlation between some of the techniques that will be used during project management and the shortening of the production cycle time. The descriptively titled ANOVA will be used to analyse the relative effectiveness of divergent techniques of project management within several manufacturing firms. Furthermore, the comparison of means and correlations will highlight the measure of association between the variables that are, the extent of project management implementation and the degree of time reduction. It is imperative to engage statistical techniques including regression analysis, ANOVA and correlation analysis to determine relationships as well as to evaluate the efficiency of various strategies in minimizing PCR on product cycle time. To start with, descriptive statistics only present the data and indicate the existence of certain patterns or utterances, which are out of the norm or not, that need to be checked for reliability and validity before it is accepted (Mertler & Vannatta, 2017; Tavakol & Dennick, 2011).

The survey data will be analysed and summarised by using descriptive statistics. For descriptive purposes we shall use quantitative analysis tools whereby variables including mean, median, mode, standard deviation and frequency distribution will establish the commonality and efficiency of project management practices in the sample population. These descriptive statistics are very important in presenting the data in a manner that is easy to understand and to look for patterns or outliers that requires more analysis (Mertler & Vannatta, 2017).

It is crucial to confirm the reliability and validity of the results that we are going to get using the questionnaire. Some of the measures include Cronbach’s alpha will be used to determine internal consistency of the questionnaire items with a view of estimating their reliability in establishing the declared constructs (Tavakol & Dennick, 2011). To assess construct validity, factor analysis will be conducted to confirm that the essence of the questionnaire is the identified dimensions of the project management practices as well as the effects on the production time.

**Qualitative Analysis**

Interview data will be inclined to the principles of qualitative data analysis and thematic analysis that helps to identify, analyse and report the patterns (themes) found in the data collected (Braun & Clarke, 2006). This approach entails coding of data, search for themes, examination of themes, identification and renaming of the themes and lastly preparation of the report. It will enable important concerns such as the critical success factors, important barriers, and the context-specific adjustments necessary for the application of several project management techniques to be discovered. Content analysis is used when the goal is quantitative data for the purpose of identifying themes, success factors and barriers about implementation of project management. These methods support the quantitative analysis as they offer the overall view of the research problem (Braun & Clarke, 2006; Krippendorff, 2018).

Also, the technique called content analysis will categorise qualitative data systematically to make meaningful inferences. This is a method whereby data is classified into predetermined codes to enable analysis of large amounts of qualitative data and to enhance a systematic way of identifying patterns (Krippendorff, 2018). The research problem is well understood since the findings from the content analysis is triangulated with the quantitative results.

## **Ethical Considerations**

Every participant’s right to personal and self-determination must be respected, and participants’ identities anonymized, hence the important of informed consent, confidentiality and ethical clearance. These measures promote trust and are legal and ethical, in response to Wiles, (2012), Babbie, (2016) and Resnik,(2018).

**Informed Consent**

Getting informed consent from all the participants is one of the most important requirements of ethical standards. The participant must have enough knowledge regarding the study itself, its goals and objectives, and the possible adverse consequences that he/ she may undergo in the entire process. This involves making sure that they are informed on how the data gathered will be used; that participation in the study is voluntary (Wiles, 2012). On the other hand, informed consent provides respect of participant’s freedom and helps protect their freedom as well.

**Confidentiality**

This is important to ensure that the participants remain anonymous to any outsider due to privacy issues. The collection will neither include individual identifiers nor names and all the names will be replaced by numbers. The data collected will be kept safely stored and this data will only be accessed by persons who have the permission to do so. This also helps in working in accordance with the set ethical standards and protection of data (Babbie, 2016).

**Ethical Approval**

In the commencement of the data collection, an ethical approval is to be sought for by preparing and submitting the application to the relevant Institutional Review Board before data collection is initiated. It will be the function of the IRB as well as we will also look at the risks linked with the study to consider and approve the research proposal first. Ethical clearances are needed to protect the participants as well as the credibility of the research work (Resnik, 2018).

**Summary**

The applied sampling techniques as well as the research tools selected for the study are expected to provide broad answers to the research problems and questions formulated above. Information-rich samples are achieved using purposive sampling while stratified random sampling guarantees a representative sample. The questionnaire, being the main quantitative tool, provides coverage, comparability and wide range of the community, whereas the semi-structured interview guide, and the case study protocol provide for comprehensiveness and context. Combined, these methods and instruments create a precise framework for the further research of the effects of the PM techniques on the production and processing time in the manufacturing industry.

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