Production Line Strategies and Operational Performance of Manufacturing Companies in Benin City

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DECLARATION

I, **Omosoria Casey OKOOBOH,** hereby declare that the work presented in this project is a genuine work done originally by me and has not been submitted elsewhere for the award of any degree. All sources of information referred to in this work are acknowledged with reference to the respective authors.

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CERTIFICATION

This is to certify that this thesis titled **"Production Line Strategies and Operational Performance of Manufacturing Companies in Benin City"** was carried out by **Omosoria Casey OKOOBOH** in the Department of Business Administration, Faculty of Management Sciences, University of Benin, Benin City.

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DEDICATION

This research work is humbly dedicated to God Almighty, who by His grace has made this day possible. He kept me throughout my academic sojourn in this great citadel of learning and provided all my needs according to His riches in glory through Christ Jesus. I am grateful Lord.

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ABSTRACT

This study examined the impact of production line strategies and operational performance of manufacturing companies in Benin City, Edo State, Nigeria. Specifically, it assessed the relationships that one-piece flow, standardised work and ergonomic conditions of the production lines have with operational performance of Manufacturing Companies in Benin City, Edo State, Nigeria.

The survey research design was adopted for this study. The population of the study comprised all the managerial staff of the 48 registered manufacturing firms in Benin City. A total of 144 copies of questionnaire were distributed, retrieved and found usable for the study. Judgemental and convenience sampling procedure was used in administering the copies of questionnaire to selected respondents in Manufacturing Companies in Benin City, Edo State, Nigeria. The data collected through questionnaire administration were analysed using descriptive statistics such as frequency distribution, mean and standard deviation. Multiple regression analysis was used to estimate the research models using the Ordinary Least Squares (OLS) technique.

The study found that there is a positive and significant relationship between one-piece flow, ergonomic conditions of the production lines and operational performance of manufacturing companies in Benin City, Edo state, Nigeria while a positive and non-significant relationship was found between standardised work and operational performance of Manufacturing Companies in Benin City, Edo State, Nigeria. It was concluded that adopting one-piece flow and a proper production line ergonomics in the

organisation will create a more productive workforce, enhanced cost effectiveness and increased profitability. The study recommends that manufacturing companies should consider adopting one-piece flow methodologies, promote a continuous and efficient production process, balance the implementation of standardised work, considering task nature, workforce dynamics, and creativity requirements, and prioritise the creation of ergonomic work environments by investing in facilities that optimize the physical and cognitive capabilities of employees. This should be supported by training programs, regular assessments and employee feedback.

CHAPTER ONE

INTRODUCTION

1.1 Background to the Study

In the global and dynamic business environment of today, the ability to meet customers' demands, improve product quality and production efficiency are some of the important requirements for achieving greater operational performance. In order to meet these requirements, manufacturing companies adopt strategies like Materials Requirement Planning (MRP), Production Line Balancing, Lean, and other strategies related to Operations Management in their manufacturing processes (Kulkarni & Naik, 2015; Ortega, Garrido-Vega, & Machuca, 2021).

Operational performance is one of the most used response variables in management research studies. This is because it gives management research scholars and managers the tools needed to assess businesses over time, and to make comparisons with competitors (Richard, Devinney, Yip & Johnson, 2009). In their work, Gavrea, Ilies and Stegerean (2021) observed that organisations are usually concerned with how to continually improve performance because performance improvement is what builds shareholders' confidence in a company. It is something that has a strong influence on the actions of business firms; the resultant effect being an increase in the number of ways by which it is being measured, creating gaps in knowledge to be filled by researchers (Jenatabadi, 2015).

In order to improve performance, Dinesh, Sathiskumar and Krishnakumar (2019) believe that manufacturing organisations can use the line balancing method to bring together all the little areas of improvement that can be discovered using Kaizen modelling approach at each workstation. To them, both production line balancing and Kaizen are tools used in lean manufacturing to remove activities that do not add value to the production process. And because of the waste reduction capability of lean, most of its tools can be implemented in the production lines of manufacturing companies to improve performance (Todorova, 2023). And a major aim of installing production lines in various manufacturing industries like garment, automotive or home appliances industries is to allow for efficient mass production of standardised goods (Hazir, Dolgui & Delorme, 2024).

In their study, Unuigbe, Unuigbe, Ehebhamen and Ekhareafo (2016), noted that the performance of any manufacturing company depends on the degree of flow of their production lines; hence a well- production/assembly line is of great importance to manufacturing companies because of its performance boosting capability.A look at Edo state shows that the state has a growing production sector that includes companies in several industries like food and beverages, textile, plastics, pharmaceuticals and construction materials (MAN, 2020). Some of these companies are Nigerian Bottling Co. Plc., Okomu Oil Palm Company Plc., Agen Longspan Industries Limited, and so many others. This research work therefore looks at the influence of production line strategies on operational performance of manufacturing companies in Benin City.

1.2 Statement of Research Problem

In recent times, many manufacturing organisations, because of the intense competitions that came with globalisation, have been compelled to find better and more efficient ways of meeting the ever changing customers' demands while minimising losses in costs, time, quantity and quality. In order to accomplish this, companies are now currently applying waste reduction techniques like line balancing, lean and other strategies relating to production and operations in their manufacturing processes (Onwughalu *et al*., 2017). Balancing a line, according to Sridhar, Anandaraj and Santhosh (2017) brings about high efficiency and effectiveness of the production plant as well as improving its productivity, with the ultimate aim of achieving customers' satisfaction and market competiveness. A production line is a line balancing situation where every task requires equal amount of time to be completed (Patil, 2021). Unuigbe *et al*. (2020) noted that the process of balancing a production line equips decision makers with the necessary information for improving production. This is because the impact of the various factors of line balancing on the production process is great.

A look at the directory of the Manufacturers Association of Nigeria (MAN), Edo State chapter, shows that there are forty eight (48) manufacturing companies currently registered with the association in Edo State. And a lot of these companies are Small and Medium Enterprises (SMEs), many of which struggle to stay in business. Even those that are able to stay afloat have weak competitive positions with so many of their local and international counterparts because of high losses in terms of costs, time or quantity.

Hence the need for waste reduction strategies (Udeze, Ugbam & Ugwu, 2018). Examining the influence of production line strategies on the performance of manufacturing companies in Benin City is the aim of this research study.

Moreover, a review of relevant literature showed that a lot of work done on production line strategies have been about achieving better capacity utilization on the factory floors (Unuigbe *et al*.,2020; Dinesh *et al*., 2019; Hosseinjani, 2017; Morshed & Palash, 2024; Qattawi & Madathil, 2019; Ubani, 2021) as well as improving production efficiencies of the companies (Bagshaw, 2020; Great & Offiong, 2023; Ikon & Nwankwo, 2015; Jameel, 2015; Onwughalu *et al*., 2017). To add to this, Wilson (2024) believes that many production line balancing researchers focus on maximising the efficiency of the lines rather than their long term operational benefits to the entire organisation. However, each of the various researchers mentioned above, apart from Bagshaw (2020), conducted their line balancing research on the production lines of one or two manufacturing companies at a time. And majority of them did their studies outside Edo state, and to the best of the researcher's knowledge, none in Benin City. They all carried out the actual balancing of the production lines using one or two balancing algorithms or heuristic methodologies (as in the case of Great & Offiong, 2023; Jameel, 2015; Ubani, 2021) and simulation software (as in the works of Unuigbe, Unuigbe, Aigboje & Ehizibue, 2016; Parvez, Amin & Akter, 2017) to minimize the number of workstations, reduce idle times, increase the line efficiencies and in some cases, reduce cycle times.

Again, to the best of the researcher's knowledge, none of the authors, from literature review, conducted a study on production line strategies and how they influence the performance of organisations. And none of the studies, to the best of the researcher's knowledge, was conducted in Benin City. This study was thereforecarried outto fill this lacuna by empirically examining production line strategies and operational performance of manufacturing companies in Benin City, Edo State, Nigeria. Specifically, one-piece flow, standardised work, and ergonomic conditions of the lines were used to proxy production line strategies in this study while operational performance was proxy using product output and product quality.

1.3 Research Questions

From the above research problems, the following research questions were coined:

1. How does one-piece flow impact on operational performance?
2. What is the relationship between standardised work and operational performance?
3. How does the ergonomic condition of a production line influence operational performance?

1.4 Objectives of the Study

The broad objective of this study is to establish the relationship between production line strategies and operational performance in manufacturing firms in Benin City. Specifically, the study seeks to:

1. find out how one-piece flow impacts on operational performance;

2. determine the relationship between standardised work and operational performance;
3. examine how the ergonomic conditions of a production line influence operational performance.

1.5 Research Hypotheses

The following hypotheses stated in the null form will be tested for this research work:

1. There is no significant relationship between one-piece flow and operational performance.
2. There is no significant relationship between standardised work and operational performance.
3. There is no significant relationship between the ergonomic conditions of a production line and operational performance.

1.6 Scope of the Study

This study looked at production line strategies and operational performance of manufacturing companies in Benin City. The forty eight (48) manufacturing companies in Benin City registered with Manufacturers Association of Nigeria (MAN) were used for this research study. This is because manufacturing companies are usually those who design production lines for their operations. The study is limited to Benin City, and the time frame is 2023, as this will make it very current as well as serve as a relevant foundation to other researchers who will want to carry out further investigative studies on the subject area in the course of the year 2023 and beyond.

1.7 Significance of the Study

This study will provide information on how operational performance is influenced by some of the strategies associated with the balancing of production/assembly lines in manufacturing companies. It will be specifically useful to the following stakeholders:

Managers: This study will be of immense benefits to managers at all levels in the industrial sector of the Nigerian economy and beyond. Meeting customers' demands efficiently is something every good manager strives for. Knowing how to achieve this without compromising on quality will be an added advantage to managers. This research work seeks to fill that gap, as it will provide information on how to remove non-value-added activities in the production processes.

Academics/Researchers: The study will be relevant to academics as it supports and adds to the existing body of knowledge on the relationship between assembly (production) line balancing and operational performance. Researchers will also find it useful if they want to embark on further investigative research on the subject area.

CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction

The purpose of this section is to review the literature relevant to the study. Specifically, it covers concept of operational performance, Measurement of operational performance, production lines, line balancing and some global production line strategies. Moreover, it reviews theories related to production and production line balancing, and presents previous empirical studies. The theoretical framework and the research gaps are also presented here.

2.2 Conceptual Review

This section focuses on the conceptual literature, which carefully examines the various concepts that are relevant to this study.

2.2.1 Operational Performance

Looking at the literature on operational performance, it is found that performance has been studied and defined in different ways (Okoya, 2023). The reason for this is that the domain of operational performance cuts across different users. This makes the construct not only complex and subjective, but also multidimensional (Richard *et al*., 2009). In their work, Uyen and Zainal (2017) defined performance as a measure of an organisation's output using market and financial indices. Suhag, Larik and Lakho (2017) saw operational performance as the actual output of a company which is measured in comparison with the intended output, goal and/objective. In his study of operational performance, Jenatabadi (2015) opined that every organisation, given their resources, must have some pre-set objectives with which they define performance. According to him, performance is defined as an organisation's ability to fully utilise its resources efficiently and effectively in the pursuit of its goals.

As defined by Adeyeye (2024), operational performance is a unit for analysing an organisation's resource input and outcome, and how this transformation process can lead to the achievement of set operational goals..To analyse and conceptualise performance, an organisation must tie it to an objective. And because an entity's objectives are unstable, contrasting and disputable, performance as a concept is highly subjective (Elena-Iuliana & Maria, 2016; Jenatabadi, 2015). Richard *et al*. (2009) defined operational performance as an action encircling three particular aspects of an organisation's output: 1. financial aspect (profits, return on assets, return on investment). 2. Market aspect (market share, sales, etc.). 3. Stock market aspect (total shareholders return, economic value added, etc.).

In his research work, Carton (2004) cited the work of some other researchers (like Alchian & Demsetz, 1972; Barney, 2001) who believe the whole purpose of performance is value creation. To them, the definition of operational performance is based on the belief that an organisation is the bringing together of contributory resources to achieve a common goal. These contributory resources, which include human beings, receive value for their contributions, which they continue to give as long as they are satisfied with the value created for them. Conversely, the organisation receiving the contributions will continue to provide value for the contributors as long as the value created from their contributions is greater than or equal to the value expected by the contributors.

2.2.2 Measurement of Operational Performance

According to Ireland, Cantens & Yasui (2021), performance measurement is a term that is normally used to explain the constant collection of statistics from the various functional units in an organisation. It involves continuously keeping track of how well the organisation is advancing towards the achievement of its set goals, and communicating such to the appropriate authorities. The measures adopted are premised on what needs the organisation has to meet at a particular point in time (Jenatabadi, 2015; Shaibu, 2024; Ireland *et al*., 2021).

Over the years, there has been a surge in the number of ways and approaches to measuring performance, with different researchers using different terminologies to explain the concept of performance measurement (Jenatabadi, 2015; Okoya, 2023; Richard *et al*., 2009). In their works, some authors like Jahanshahi, Rezaei, Nawaser, Ranjbar and Pitamber (2021) have favoured the use of the traditional financial measures while others like Carton (2004) and Okoya (2023) have adopted the non-financial and other measures of performance. Jahanshahi *et al*. (2021) adopted three types of measures for operational performance. They are financial performance measures, operational performance measures and market-based measures. Okoya (2023) favours the use of fully subjective measures in her work. These measures allow organisations and researchers to use self-report questions that look directly at the fundamental performance constructs (Richard *et al*., 2009). Quesado *et al*., (2017) highlight some benefits of using the Scorecard (BSC) as a measure of operational performance. Kaplan and Norton (1992), as cited in Quesado *et al*. (2017) states that the BSC acts as a tradeoff between the internal indices associated with seriously demanding processes like learning, innovation and growth and external indices related to stockholders and customers. It consists of four measures such as financial, market/customer, internal business processes, and learning and innovation factors (Kaplan & Norton, 1996), as cited in Shaibu (2024).

Many authors in the literature have written on the use of financial measures, which are usually ratios or percentages such as Return on Investment (ROI), Return on Asset (ROA), Earnings before Interest and Taxes (EBIT), etc., as a way of measuring performance in the organisations (Bakotic, 2016; Carton, 2004; Ntuara, 2008). However, the use of financial measures of performance as used in accounting and finance disciplines is inadequate because they do not reflect future outcomes and opportunities (Carton, 2004; Okoya, 2023). There is therefore the need to bring in other variables that reflect such outcomes for organisations, hence, the adoption of the non-financial and other measures of performance. In the work of Adeyeye (2024), the measure of performance was not carried out with financial indicators alone; instead, other performance measuring variables like sales level, financial strength, staff quality, employee productivity and goodwill were combined to measure operational performance.

These added variables show the multidimensionality of operational performance; as there are the human resources, marketing and strategic planning dimensions in the organisation.

Looking at the performance measurement process developed by Gavrea *et al*. (2021) reveals their advocacy for the use of both the financial and non-financial indicators in an organisation's performance measures, especially in manufacturing organisations. To them, it is difficult to satisfactorily measure a company's performance using a single construct. This again alludes to the complexity and multidimensionality of operational performance arising from different stakeholders within and outside the organisation whose activities have a direct bearing on the organisation (Richard *et al*., 2009).

Measuring the impacts of line balancing on the performance of manufacturing companies in Rivers State of Nigeria, Bagshaw (2020) used production efficiency, which he further broke down into product output, product quality and lead-time reduction as proxies for performance measurement. In this research work, performance will be measured using some combination of financial and non-financial measures, which are: product output and product quality. Product Output is the quantity of goods produced in a specific time period using availableresources (Ireland *et al*., 2021).Razak (2016) defined product qualityas the extent to which customer satisfactions are met by the inherent elements in a product.

2.2.3 Concept of Production/Assembly Lines

According to Spacey (2017), a production line is a type of production system that has a series of processing steps. At each step is a workstation, where an operation is carried out bringing the item closer to being a finished product. It could also be seen as a manufacturing configuration consisting of a set of workstations serially arranged, with each workstation linked to the other by a material handling devices like conveyor belts or chains (Unuigbe *et al*., 2016). Chen (2019) defined Assembly line as a manufacturing procedure that divides the production of an item into different stages that are completed in a sequence determined beforehand. "It is a production sequence where parts are assembled together to form an end product" (Telsang, 2021:275). A workstation is a point in the production/assembly line where the machines (which could be robots) and equipment for carrying out operations on the work piece are placed (Bierbooms 2021; Saif, Guan & Jahanzaib, 2024). In some cases the workstations are manned by one or more persons or a combination of machines and persons (Bierbooms, 2021).

There are numerous business sectors where production/assembly lines are normally used, for example, in the electronic appliances industry, automobile industry, in garment manufacturing industry, beverage industry and a host of others (Bierbooms, 2021; Hazir, Delome & Dolgui, 2024). The whole purpose of a production line is to allow for the production of large quantities of similar (standardised) products in industries, as quickly and as cost efficiently as possible (Dolgui & Gafarov, 2017; Shinde & More 2015; Wilson, 2024). The jobs performed by assembly line workers are usually repetitive, leading to a high specialisation of labour(Akhter, Siddique & Shorif, 2016). There is also the issue of ergonomics, which deals with how the lines are designed taking workers' wellbeing into consideration (Polat, Mutlu & Ozgormus, 2018).

Some of the most common measures of the performance of a production line according to Bierbooms (2021) are the throughput, the mean flow time, the idle time, the line efficiency, cycle time, takt time, work pieces, precedence constraint, bottleneck, lead time and so many others. From literature, different authors have attempted to explain the meanings of these production lines' performance measuring concepts. Kothavade, Kulkarni, Ghuman and Deshpande (2015) explained some of these concepts as follows:

Cycle Time is the maximum amount of time that is given to work on an item at each workstation. It is the time allotted for the completion of each task in the production line. It is expressed mathematically as the ratio of the production time per day to the required number of unit per day as shown below:

$$Cylcle\ Time = \frac{\text{Available production time}}{\text{Required number of units}}$$

Idle Time is the time that a particular machine or machines are functioning at the required parameters, but are not processing any item, usually due to delay in carrying out tasks in some workstations or due to bottleneck activities. Bottleneckisthe part of the production line that hinders the achievement of higher output. They are to be identified, and then eliminated by line balancing. Lead Time is the time that elapses between when an order is placed for a product and when it is delivered to the customer placing the order. It is the sum of the Cycle time and the additional amount of time it takes to begin production and deliver the finished products to clients.

Efficiency of a Production Line describes in percentage the number of hour a production line stays functional during production. It is expressed mathematically as shown:

$$Efficiency = \frac{Sum\ of\ task\ times}{\text{Cycle times x Number of actual workstations}}$$ i

Great and Offiong (2023) explained some of the production line constructs as shown below:

Work Piece (Element) is the individual task into which the entire work content may be divided along the production line. Each element indicates the task to be performed and the standard time required to perform the task. Work Contentis the sum of all the work pieces on the production line. The throughput of a production line is the number of items produced per unit of time. It is also referred to as the production rate (Bierbooms, 2021). Eriksson (2020) defines Takt Time as that rate of production which depends on the rate at which customers place demand on a specific product; a measure of the pace at which an item or a product must be produced in order to meet customers' demand. Takt time is different from cycle time, which is not dependent on the demands of customers (Eriksson, 2020). A change in takt time is usually triggered by a change in customers demand (Qattawi & Madathil, 2019). According to Soliman (2020), the word "Takt" is a

German word for “Pace”. It talks about the steady beat which production must follow in order to meet the demands of customers. Mathematically, it is expressed as:

$$\text{Takt time} = \frac{\text{Available production time per shift}}{\text{Rate of customers' demand per shift}}$$

2.2.4 Historical Overview of Production Lines

Historically, the making of production lines is believed to have started in the middle ages when miners developed bucket elevators to ease movements during their mining operations (TryEngineering, 2020). It can also be traced back to the fourteenth century when builders of ships made moving lines for ship parts and components. However, it was not until the 1900s that the use of production lines was adopted by companies in many industries for milling, shipbuilding, canning, packing of meats, and many others (TryEngineering, 2020). The modern day use of assembly lines was popularised by Henry Ford with his 1913 successful implementation of the techniques in the assembling of his Model T automobiles (Unuigbe *et al*., 2021; TryEngineering, 2020). It is said that Henry Ford got the idea from the Oldsmobile assembly company, owned by Ransome Olds, a man who created and patented the assembly lines in 1901 (Corday, 2024).

The assembly line approach used by Ford is what is today called Just-In-Time (JIT) manufacturing (TryEngineering, 2020). The elements that constitute JIT were developed by Toyota Motor Corporation just after World War II with the introduction of the Toyota Production Systems (TPS), from which lean manufacturing principles were drawn (Sharma, Kasher, Zhang, Mani & Lai, 2018). The introduction of TPS helped the company to reduce operational costs, enabling it compete with its German and American counterparts, which had lower relative car prices (Sharma *et al*., 2018). Lean manufacturing is a term used to describe manufacturing strategies that focus on meeting customers' desires by making quality products available to them at the least possible cost after eliminating all forms of wastes in the production process (Keitany & Riwo-Abudho, 2024). In attempting to allow for flexibility and maximum efficiency in his operations in the early twentieth century, Henry Ford first used the techniques of line balancing informally in his production process (Wilson, 2024).

The practice of balancing assembling lines was of little or no interest to so many authors and organisations until it was popularised by the author, Melvin E. Salveson in his 1955 publication where he adopted the use of some operations research methods in balancing the lines (Battaia & Dolgui, 2023; Unuigbe *et al*., 2021; Wilson, 2024).

2.2.5 Classification of Assembly Lines

There are different classifications of assembly lines according to different researchers. From literature, Saif *et al*. (2024), and Ahmadi and El-Abbadi (2020) agreed there are six different classifications of assembly lines and types based on their characteristics. They classified them into 1. Assumption characteristics: which include the simple and the generalised assembly lines, 2. Layout Characteristics: which include the serial assembly lines, the parallel assembly lines, the U-shaped assembly lines, and the two-sided assembly lines, 3. Workflow Characteristics: which include the paced and un-paced assembly lines, 4. Objective Characteristics: which include the single objective and multi objective assembly lines, 5. Product Characteristics: which include single Model assembly lines, mixed model assembly lines and multi model assembly lines, and 6. Task Time Characteristics: which include the fixed task time assembly lines, variable task time assembly lines and the stochastic task time assembly lines.

The simple assembly lines, which are the same as single model assembly lines (SMAL) are used where only one variant of an item is produced. General assembly line on the other hand is used to refer to situations where you have multi-purpose assembly lines like the parallel assembly lines, mixed model assembly lines, U-shaped and two-sided assembly lines (Kamarudin & Rashid, 2018). The mixed model assembly lines are used where different models of an item are produced on the same line at the same time without changeovers. They are sometimitres used in job-shops for the production of customised items for different customers at the same time (Dinesh *et al.*, 2019; Thomopoulos, 2024). Changeovers are those alterations that are made to the production lines to enable them handle a different model of a product during batch processing (Eriksson, 2020). The multi model or batch production lines are used where several models of a product are produced in batches. Each batch runs simultaneously on the production line until the desired inventory level is reached, and then changeovers are made to prepare the line for the next model of the same product to be handled

(Thomopoulos, 2024). Paced assembly lines, according to Saif *et al*. (2024) are lines where every workstation is given equal cycle time and no need for a buffer. The items can be passed from one workstation to the next workstation for processing only after the cycle time elapses. The fixed cycle time value is usually determined by the amount of time required to perform the bottleneck activity.

Un-paced assembly lines on the other hand are lines where each workstation machines or operators are allowed to operate at their own speed. These kinds of production lines allow the installation of buffers (temporary storage spaces) between workstations, which help to minimise waiting times in the production process. In this situation, an operator could be “starved” or “blocked”; starved if the workstations before them delay in completing their tasks and sending the work-in-process items over; blocked if the workstation after them delay in sending the work pieces to the buffer ahead. Unpaced production lines can be further divided into synchronous and unsynchronous production lines (Ahmadi & El-Abbadi, 2020; Saif *et al*., 2024).

There are different techniqhues used by manufacturers to improve the performance of their production lines, they are: the use of lean tools, the use of different commercial simulation software, classical mathematical models, integrated approach, heuristic-algorithm approach, and so on (Rane & Sunnapwar, 2017). These various performance enhancing techniques of the production lines by researchers adopts the use of assembly line balancing or redesigning technique (Dinesh *et al*., 2019; Qattawi & Madathil, 2019).

Tatum (2023) identified three different kinds of production/assembly lines designs: the straight line, the U-shaped, and the mixed model assembly line designs. In the straight line design, there is a single line running in one direction with the workers performing their tasks from each workstation on the line. These are usually adopted in small business settings. The U-shaped lines on the other hand, are usually adopted where there is a small amount of space. This configuration allows the introduction of items at one end, and the conveyance of such items around a loop that is open-ended like a horseshoe (Tatum, 2023). Lastly, the mixed mode assembly line combines the characteristics and the advantages of both the single assembly line and the U-shaped assembly line while minimising the errors associated with both. They are normally used where various models of products are produced in a single assembly line (Dinesh *et al*., 2015).

2.2.6 Concept of Production Line Balancing

The production lines are designed in such a way that operations are carried out on the unfinished products at each workstation. The unfinished products go from one workstation to another in a moving line until they come out at the other end as finished products (Kothavade *et al*., 2015; Great & Offiong, 2023). These movements follow a pre-defined order known as precedence constraints. These precedence constraints are usually given in the form of a table or a diagram (Akhter, Siddique & Shorif, 2016; Ubani, 2021). There are some situations where the workloads in the stations are un because some of them have more tasks than others or because the amount of time allotted to some stations are not commensurate with their workloads. Stations with more tasks usually require more processing times to complete the tasks, which usually leads to idleness of stations with less work but with the same amount of time. This can bring about a delay of the entire production process and the company's ability to meet customers' demands on time (Ikon & Nwankwo, 2015; Syahputri, Leviza, Rizkyat, Napitupulu & Anizar, 2018).

Production line balancing involves optimising the division of production workloads among each workstation by taking cognizance of certain underlying objectives (Saif *et al*., 2024). According to Kothavade *et al*. (2015:154), "Line Balancing is leveling the workload among all processes in a cell or value stream to remove bottlenecks or excess capacity". The main purpose of balancing an assembly line is for jobs to be evenly distributed among the workstations in order to minimise the idle times of machine and man (Ikon & Nwankwo, 2015). Eriksson (2020) believes that to achieve optimum balance of an assembly line, the cycle time should be equal on all the workstations.

The definitions above show that line balancing deals with the problem of how well tasks are divided among workstations so as to improve the performance of production lines. The performance of manufacturing companies is highly dependent on the degree of flow of their production lines with regards to output (Unuigbe *et al*., 2020). Consequently, managers in these companies are very much interested in how well these lines perform, because it guides them in making some strategic decisions in the organisation (Unuigbe *et al*., 2020). These line balancing methods are therefore some of the tools used by managers to enhance performance in the factory floors (Unuigbe *et al*., 2020; Dinesh *et al*., 2019; Great & Offiong, 2023; Kothavade *et al*., 2015; Syaputri *et al*., 2018). A production/assembly line, according to Patil (2021), is a line balancing situation where every task or work element requires equal amount of time to be completed. When an assembly line is , all its workstations will have the same processing and cycle times with no need for waiting times between them (Eriksson, 2020).

Assembly Line balancing problems can be divided into two; Simple Assembly Line Balancing Problems (SALBP) and Generalised Assembly Line Balancing Problems (GALBP) (Battaia & Dolgui, 2023; Kamarudin & Rashid, 2018). The SALBP involves a single straight assembly line with the objective of producing only a single item while the GALBP considers different objectives with different assembly line configurations, like the U-shaped, the mixed model, the two sided and the parallel assembly lines (Battaia & Dolgui, 2023). Many authors have carried out studies on line balancing problems in several ways, with many of them paying more attention on the SALBP (Polat *et al*., 2018). The SALBP is divided into two types, referred to in literature as Type-1 and Type-2 assembly line balancing problems or SALBP-1 and SALBP-2 respectively (Battaia & Dolgui, 2023; Hazir & Dolgui, 2019; Ikon & Nwankwo, 2015; Polat *et al*., 2018, Sridhar *et al*., 2017). The Type-1 involves minimising the number of workstations at a given cycle time while the Type-2 involves minimising cycle time for a given number of workstations (Dolgui & Proth, 2023). A third and a fourth SALBPs are found in the work of some authors like Kriengkorakot and Pianthong (2007) who referred to them as SALBP-E and SALBP-F respectively. According to them, the SALBP-E involves maximising line efficiency while SALBP-F is used to obtain a feasible balance for a given minimum number of workstations and cycle time.

Chen *et al*. (as cited in Sridhar *et al*., 2017) described another assembly line balancing problem which deals with maximising the workload smoothness for a given number of workstations. They called it Assembly Line Balancing Problem three (ALBP-3). Kriengkorakot and Pianthong (2007) described this line balancing problem as a General Assembly Line Balancing Problem (GALBP) because it is a general balancing problem which can be applied in the U-lines, the mixed model assembly lines as well as the simple assembly lines situations.

There are modern strategies in literature that are associated with the balancing of production lines. Some of them are: ergonomics (Polat *et al*., 2018), One-piece flow (Soliman, 2020), and Standardised work (Mlkva *et al*., 2016). Ergonomics is the science that deals with the arrangement of the workplace, products and systems in a way that optimizes the wellbeing of the workers as well as the overall performance of the system (Black, Neumann & Noy, 2021). Polat *et al*. (2018) wrote on how repetitive works, and sometimes, heavy lifting by production line workers can lead to injuries or impact negatively on their health, which in turn leads to high production cost for the company in terms of medical expenditure. To solve this problem, Mutlu and Ozgormus (as cited in Polat *et al*., 2018) suggest that whenever there is a move to balance the production line, the optimisation of the physical workload and the ergonomical condition of each workstation should also be considered.

According to Soliman (2020),One-piece flow(also referred to as continuous flow manufacturing) is a kind of production system where materials processed or produced are moved through the production line one unit at a time or a small batch at a time from the first stage to the last stage. With this method a defect on an item (job unit) is easily spotted and will affect that item only. One-piece flow is different from the traditional mass production techniques where items are produced or processed in batches. There are usually no buffers between workstations, hence, no work-in-process inventory (WIP) in this kind of production system (Ani, 2021; Soliman, 2020). They are mostly adopted in a cellular manufacturing environment where the objective is to make one part correctly at a time every time. This helps to remove the lengthy queue times and unscheduled interruptions (Ani, 2021).

Standardised work is another line balancing concept that according to Mlkva *et al*. (2016), is a systematic documentation of the most current best strategies for performing a job task, which the workforce must be taught to apply in each operation. It is mostly adopted when a production job requires completing a series of tasks (Krichbaum, 2008). They are introduced to reduce variations in the system brought in by the workers and to remove unnecessary motion (Krichbaum, 2008). There are three important elements of standardised work: the current takt time, the standard or in-process inventory and the work sequence (Krichbaum, 2008; Mlkva *et al*., 2016). The work sequence is the best method and process that must be followed sequentially to produce an item (Krichbaum, 2008).

A key aspect of applying standardised work is the process documentation which serves as a standard that is referenced whenever new workers are to be trained on the job (Krichbaum, 2008; Mlkva *et al.*, 2016). How the job should be done is clearly communicated to them. This helps to create understanding and awareness among the workers as each person knows their job and how to do it (Ghatorha & Sharma, 2019). This current best practice for the tasks usually serves as the baseline for further improvement (Mlkva *et al.*, 2016).

According to Kumar and Yadav (2022), several methods are used by authors in carrying out the actual balancing of production lines. Some of the basic ones adopted are the Enumeration method, the Hoffman method, the Computer Method for Sequencing Operations for Assembly Lines (COMSOAL), the Kilbridge and Wester Method (KWM), dynamic programming method, Moddie-Young Method, candidate matrix method (Salveson), Ranked Positional Weight (Helgeson-Birnie), probabilistic assembly line balancing method, Largest Candidate Rule Method, and so on (Ahmed, Sakib, Hridoy & Shams, 2020; Kumar & Yadav, 2022). From the review of literature, of all the different heuristics methods, the most commonly adopted are the Largest Candidate Rule (LCR), the Ranked PositionalWeight (RPW), and the Kilbridge and Wester Method (KWM) (Ahmed *et al.*, 2020; Ayat, Elmahi, sarfraz & Ibrahim, 2017; Jaganathan, 2024; Manaye, 2019).

The LCR technique, according to Ayat *et al*. (2017), involves the arrangement of work elements in a list from the one with the highest task time to the one with the lowest task time. The work elements are then assigned to the stations by starting at the top of the list and working down, selecting the first feasible task for placement at the stations (Manaye, 2019). The condition for feasibility involves satisfying the precedence requirement in a way that does not cause the sum of the task times in a station to be greater than the cycle time (Trung & Le, 2019). According to Ginting and Nst (2020), the RPW technique was invented by Helgeson and Birnie in 1961. This technique takes into consideration the time allotted to a task and the position of the task in the precedence diagram. To calculate the RPW of a work element, you must add its task time to the task times of all elements that follow it in the arrow chain of the precedence diagram. The RPW of the elements are then arranged in a descending order before being assigned to the workstations without violating the precedence constraint and the cycle time value (Ginting & Nst, 2020; Manaye, 2019).

Panchal and Deshpande (2020) define the KWM as a heuristic procedure which assigns work elements to stations according to their positions in the precedence diagram. The procedure begins with constructing a precedence diagram in such a way that the nodes representing tasks of identical precedence are arranged in columns. The tasks are then listed in the order of their columns, starting from column 1 at the beginning of the list to the last column. If a task can be in more than 1 column, such a task should be shown in the different columns to indicate the transferability of the task. The task elements in each column are then assigned to each workstation from first to last (Panchal and Deshpande, 2020).

2.2.7 An Overview of Manufacturing Industry in Nigeria

The Nigerian economy was designed in a pattern typical of an underdeveloped nation (Chete, Adeoti, Adeyinka & Ogundele, 2016). The manufacturing sector of the economy constitutes only a small portion of the economic activities while the oil and gas sector is the major contributor, accounting for more than 95percent of the earnings from export (Chete *et al*., 2016; National Bureau of Statistics [NBS], 2024). According to NBS (2024), the Nigerian manufacturing industry contributed about 10 percent of the total Gross Domestic Product (GDP) yearly before the oil boom of the 1970's. The increased revenues from the oil sector in the 1970's shifted the government's attention away from manufacturing, causing the manufacturing sector's relative contribution to the GDP to decline; though the sector still experienced growth, but at a slower rate. The oil boom of the 1970's actually coincided with the time of the second national development plan (1970 -1974); a period where the manufacturing sector depended so much on imported inputs (Chete *et al*., 2016; NBS, 2024). During this period, national industrial planning was done in the public sector, as most industrial projects were executed by that sector. The government invested directly in projects through the public sector because the skills and the technical know-how to undertake industrial projects were lacking among Nigerian entrepreneurs (Chete *et al*., 2016; Sola, Obamuyi & Adekunjo, 2023). This made the Nigerian government rely heavily on foreigners for things like feasibility studies and reports, engineering drawings and designs, project preparation, construction, and many other professional skills when industrial projects were to be undertaken (Chete *et al*., 2016).

The NBS (2024) showed that the 1972 Act of Indigenization of Enterprises Operating in Nigeria, which was subsequently replaced by the Nigerian Enterprises Promotion Decree of 1977 led to the conversion of majority of foreign owned companies to Nigerian owned. This action restricted the inflows of foreign capital, and consequently, the inability to afford imported goods, as well as the absence of foreign technology. These, according to the Bureau, encouraged the local production of basic commodities like salt and soap. However, Sola *et al*. (2023) opined that the fall in oil prices in the early 1980's led to a reduction in oil earnings, bringing about a recession which caused the policy attention to be turned back to the manufacturing sector, with a focus on steel production. Various policy measures like the stabilization measures of 1982, the restrictive monetary policy and stringent exchange control measures of 1984 and later, the structural adjustment programme of 1986 were adopted by the Nigerian government to cushion the effect of the oil price crash on the economy and to reduce the economy's high dependence on crude oil (Chete *et al*., 2016; Sola *et al*., 2023). Some of these policies proved abortive, but the structural adjustment programme, according to NBS (2024) encouraged import substitution which made the producers of intermediary inputs to produce again competitively with fewer plant closure.

Nigeria is still heavily dependent on the export of crude oil today as she has been some 50 years ago, causing the manufacturing sector's relative contribution to the GDP to be on a decline (NBS, 2024). Many competitive companies have moved their factories to other countries. The few key industries keeping the sector afloat are the beverages, textile, tobacco and cement, which currently are operating under half their capacity (Manufacturers Association of Nigeria [MAN], 2020).. The issue of poor electricity supply, high interest rates on loans, multiple taxations, and the difficulty in conveying imported raw materials from Lagos ports to business premises due to huge traffic congestion and bad roads are some of the problems still faced by manufacturing companies in Nigeria today (MAN, 2020).

2.3 Theoretical Review

This section presents some theories that are related to production lines. The theories include the theory of production, the theory of constraint, the lean theory and transformation model.

2.3.1 The Theory of Production

The first general physical theory of production was introduced by Jean-Baptiste Say (1803) as cited in Christensen (2004). It is an economic theory that attempts to explain the rules guiding how a company decides the amount of commodity it will produce and/or sell and how much input in terms of labour, plants, machinery, raw materials, and so on, that it will employ in the production process.

The theory also talks about the relationship between the prices of items produced and the prices of the factors of production used to produce them on the one hand, and the relationship between the quantities of these items produced and the quantities of the factors of production employed on the other hand. It is one of the two subdivisions of economic theory, and it is concerned with the way societies use available natural resources to make tangible and intangible goods (Christensen, 2004). The different productive decisions made by any business venture can be categorised into three levels of growing complexity. The first level of complexity is called the short-run minimisation, which includes decisions about the modes of producing selected quantities of the item in a plant of a given size and equipment. The second level, known as the short-run profit maximisation, includes finding out the most profitable quantities of items to make in any given plant. The third level of complexity, known as the long-run profit maximisation is concerned with the determination of the most beneficial size of plant and equipment (Dorfman, 2016).

One benefit of this theory is that it gave researchers a good understanding of the relationship between capital and labour, leading to the system of mass production, which brings about lower labour costs since organisations do not have to hire and pay for skilled labour to get their jobs done. Another benefit of this theory is the reduction in the prices of mass-produced items as a result of lower production cost.

This theory has some criticisms levelled against it. According to Beaudreau (2016), the neoclassical theory of production goes against the basic laws of mechanics because it is only energy/force that can be physically productive. He also says that the 'theory of production' is actually a misnomer as it is a little more of a simple and multiple correlations than it is a theory.

2.3.2 The Theory of Constraint

The theory of constraint (TOC) is a process improvement method that was developed by Goldradtt and Cox, as cited in Simsit, Gunay and Vayvay (2024), emphasising the importance of identifying the constraints or bottlenecks in any given system. The TOC shows that in any production system there is at least one bottleneck process that prevents it from achieving higher levels of performance (Pozo, Tachizawa, Takeshi & Picchiai, 2009). Rather than thinking they are non-dependent on each other, the theory of constraint (TOC) views processes in a system like they are rings in the same chain. A chain can only be as strong as it its weakest link. The weakest link being the bottleneck process or the system constraint that needs to be identified and managed (Simsit *et al*., 2024).

After resolving optimisation problems for some systems with a large number of constraints using linear programming, researchers and practitioners of the TOC made the claim that it is very unlikely in reality to have a system with more than three bottlenecks (Pozo *et al*., 2024). According to Goldratt and Cox (1984), the following are the on-going improvement steps for identifying, exploiting and managing a system's bottleneck(s): identify the system's bottleneck(s), decide how to exploit the bottleneck(s), subordinate everything else to the above decision, elevate the bottleneck, and go back to the first step if the bottleneck has been broken in any of the steps above, but do not allow Inertia to cause a system bottleneck.

Simsit *et al*., (2024) espouse the Goldratt's idea that inventory, throughput and operating expenses are the performance measurement of any system. According to them, one of the determinants of the performance of any production system is the amount of effort that is put on the bottleneck activities to improve the throughput at that level. This means that the first step of identifying the bottleneck activity as the weakest link in the entire system is a very important step in the on-going improvement process (Simsit *et al*., 2024). In their work, Goldratt and Cox (1984) stated that to identify the bottlenecks means to also prioritise them depending on how they affect the system's set objectives. The second step of deciding how to exploit the bottlenecks is the same thing as finding the right policies to managing the bottleneck activities.

In a production line, this is usually achieved by spreading the tasks to other parts of the system. If more hands are required on the bottleneck activities they are supplied from the non-bottleneck activities. Everything else in the system is employed in resolving the bottleneck activities. Once the bottleneck is broken or resolved another one appears to limit the system's performance, leading again to the first step (Goldratt & Cox, 1984).

2.3.3 The Theory of Lean Manufacturing

Lean theory is a reform process that demonstrates the set of principles that assists organisations to reduce wastes by using the least amount of energy, effort, equipment, space, materials, time and other resources while meeting customers' needs (Womack & Jones, 2003). The concept of lean started from the Toyota Production System (TPS) and was originally used by the manufacturing industry for achieving low cost, reduced throughput times, high variety and high quality products to meet the ever-changing customers' needs.

Though they took a cue from Henry Ford's design of the Assembly Lines in the early 1900s, Taiichi Ohno, Kiichiro Toyoda and other people at Toyota invented the Toyota Production System (TPS) which is today referred to as Lean (Lean Enterprise Institute, 2021). The TPS was invented after World War II in the early 1950s, but became well established in the 1970s in many Japanese companies. It gradually started becoming a global practice in the 1980s as manufacturing companies in the United States like General Electric (GM), Pratt & Whitney (P&W) and a host of others adopted it (TryEngineering, 2020). The word "lean" was actually coined by John Krafcick in his 1988 paper entitled "Triumph of the Lean Production", which was published in Sloan Management Review (Grabam, 2010). The term was coined in reference to the then two current production system paradigms: Recent Fordism and TPS. Krafcick changed the names, *RecentFordism* and *TPS* to *Buffered* and *Leanproduction systems* respectively. James Womack, who was a thesis advisor to Krafcick at the Massachusetts Institute of

Technology (MIT) later popularised the term ‘lean” by adopting it in his book *The Machine that Changed the World* (Grabam, 2010; Zarbo, 2015).

Lean or lean manufacturing as it is usually called has five principles as highlighted by Womack and Jones (2003). They are: Value specification, Value stream identification, Flow, Pull and Pursuit of perfection. Value Specification is the first principle of lean; it states that what constitutes value can only be defined from the point of view of the customer. The Value Stream principle states that with lean you are to clearly spell out all the steps and actions that add value to the production process and those that do not, which should be eliminated. The next principle is Flow**,** which is one of the well-known strategies of lean manufacturing. The value-creating steps are made to flow without any hindrance. The Pullprinciple states that you do not make anything until it is needed by the customers, and should be made very quickly. The last principle is the Pursuit of Perfection**,** which states thatlean is a process of continuous improvement.

Unnecessary waiting and underutilisation of workers are some of the nine (9) identified lean wastes according to Womack and Jones (2003). These two sources of wastes lead to idle time, which brings about balance inefficiency in a production line. Line balancing, which is one of the tools of lean manufacturing is used to eliminate this imbalance (Dinesh *et al*., 2019). There are several lean manufacturing tools in the literature. Some of them are Just-in-Time (JIT), Kaizen, Total Quality Management (TQM), Cellular manufacturing, Kanban, Value stream mapping, Poke yoke, 5S (Sort, Straighten, Shine, Standardise and Sustain), and Total productive maintenance (Dinesh *et al*., 2019; Onwughalu *et al*., 2017).

Introducing lean into the production system will help any company to double their productivity, reduce throughput time, reduce inventory by 80 percent, cut errors by 50 percent, improve product quality, cut injuries, and improve system flexibility in reacting to changes (Onwughalu *et al*., 2017; Womack & Jones, 2003). However, lean like other production strategies, has its drawbacks. Some of them are: very little or no consideration for the human aspect, thereby over stressing the workforce; increase in job responsibilities without commensurate increases in remunerations; absence of a standard production model or methodology; and the inability to cope with variability because of the absence of production contingency plans (Keitany & Riwo-Abudho, 2024; Onwughalu *et al*., 2017).

2.4.4 Transformation Model

The transformation model explains how the three components of business operations, namely: the input, the conversion process and the output are used in all organisations to produce goods and/or provide services for customers (Bauto, 2022). It talks about how inputs or resources are transformed into finished goods or services, known as the output, for consumers (Horvathova & Davidova, 2021). According to Bauto (2022), resources (inputs) are classified into two; transformed resources and transforming resources. The transformed resources are those that are converted into goods or services in the process of transformation while the transforming resources are the personnel involved in providing services to the transformation processes. They are sometimes referred to as labour. The plants and machinery used in business facilities are operated by the transforming resources (Braciotti, 2017). The resources, as explained by Bauto (2022), whether transformed or transforming, are of three types, namely: the material the physical input to the process, the information being processed, and the customers, which are the people being transformed in some ways.

The process of transformation usually results in some outputs. The output may be in the form of tangible goods and intangible services, as well as some wastes (Bauto, 2022). The output is the final product that is delivered to the customers or the end of a service rendered to a customer (Slack, Brandon-Jones, & Johnston, 2023). An important part of the transformation system in many organisations is the minimisation of the impact of wastes on the environments throughout the entire life cycle of their products (Bauto, 2022). The next aspect of the transformation model is the transformation process itself. The transformation process is any activity or set of activities that takes one input or multiple inputs and convert them into outputs by adding value to them (Bauto, 2022; Braciotti, 2017). The conversion is usually in the form of a change in the physical features of materials or customers; could also be in the form of changes in the location of information, materials, customers, amongst others (Braciotti, 2017).

2.4 Theoretical Framework

Based on the review of the theories on production line balancing, this study is anchored on the theory of constraint. The theory of constraint emphasises the importance of identifying the bottlenecks in any given system and dealing with them (Simsit *et al*., 2024). A proper balancing of an assembly line helps to identify the bottleneck activities and also helps even out the workloads in all the workstations including the bottleneck station(s). A good understanding of the theory of constraint will help production manager prepare for and handle possible bottlenecks in the production system. This is the justification for adopting the theory of constraint for this study.

2.5 Empirical Review

This section shows previous studies on the relationship between the independent variable and the dependent variable. In balancing an assembly line there are two objectives that are usually met. In some situations the number of workstations is optimised for a given cycle time (often referred to as type-1 or ALBP-1). This is usually done in situations where the demand and production rates are known. The Assembly line balancing type-2 (ALBP-2) involves the optimisation of cycle time for a given number of workstations. This type is adopted when the production rate of a given item is to be maximised (Raj, Jeeno, Peter & Gishnu, 2016).

Giray *et al*. (2018) carried out a study on the production capacity optimization of a Heating, Ventilation, and Air-conditioning (HVAC) assembly line in an automotive company. The study was done in Turkey. The purpose of the study was to minimise the cycle time of the two products of the HVAC automotive company, the manual and automatic Air-conditioners. An integral programming model was adopted for the study using a commercial software package: Mathematical Programming Language (MPL). The result was a reduction in cycle time by 10% and an increase in the efficiency of the line. It also leads to a huge increase in the number of products without any further investment by the company.

Polat *et al*. (2018) did a study on a mathematical model of assembly line balancing problem type-II under ergonomic workload constraint. The study was carried out in Denizli, Turkey. The aim of the study was to improve the performance of an assembly line by simultaneously balancing the cycle time and the physical workloads of the line. A goal programming model was used to solve the problem. And in other to validate the model, a small-sized instance of the problem was solved using goal programming software developed by the International Business Machine (IBM) - Ilog Cplex optimisation studio 12.7.1. The result of the study showed that physical workload considerations when carrying out cycle time reduction in a production line can reduce the risks of work-related musculoskeletal disorders in workers. This can bring about an increase in performance of the production line while also cutting down costs for the company.

Chutima and Suphapruksaspongse (2004) conducted a research on practical assembly line balancing in a Monitor manufacturing company. The study was conducted in Thailand. The purpose was to give a pragmatic approach to balancing and synchronising a Monitor assembly line in other to reduce its throughput times despite the several manufacturing constraints. While the Computer Method of Sequencing Operations for Assembly Lines (COMSOAL) and current factory heuristic methods were used to balance the line, a 3-factor experimental design containing line balancing methods, line balancing algorithms and conveyor speeds were carried out to evaluate the significance of some of the factors measured. The results showed that the line balancing methods and line balancing algorithm provide significant improvements to the line efficiency, output and throughput time.

Akhter *et al*. (2016) conducted a study on improvement in productivity by developing an efficient line. The study was conducted in Bangladesh, and the purpose of the study was to increase the balancing efficiency of an assembly line so as to improve the productivity and profitability of an automobile company without the introduction of additional resources. They used the COMSOAL algorithm to find out the trends and developments available in industries in order to minimise the total equipment cost and the number of workstations. The result obtained showed that the proposed model will lead to an increase of 3.6% in balancing efficiency while the idle time will be reduced also by 3.6% for the company.

The result of a study carried out by Ngadima, Rasi, Aziati, Chan and Ramilan (2016) on line balancing scorecard for production lines in SMEs showed that of the different kinds of production lines and their balancing, the mixed model line balancing gives the most positive impact on the performance of an SME producing a dough pizza. They carried out the study in Malaysia using survey research design. The data were collected by observation, and the analysis of data was done using a time study approach.

Raj *et al*. (2016) did a research on optimisation of cycle time in an assembly line balancing problem. The study was carried out in India. The purpose of the study was to maximise the production rate of a mixed model assembly line for a given number of workers. They used Genetic Algorithm as the meta-heuristics method to handle the cycle time optimisation problem in parallel workstations. The result revealed that in a mixed model assembly line, the Genetic Algorithm procedure can be used to get the optimal cycle time value that will increase the production rate.

In India, Vishnu *et al*. (2016) did a research on optimisation of cycle time in an assembly balancing problem. The purpose of the study was to maximise the production rate of a mixed model assembly line for a given number of workers. They used Genetic Algorithm as the meta-heuristics method to handle the cycle time optimisation problem in parallel workstations. The result revealed that in a mixed model assembly line the Genetic Algorithm procedure can be used to get the optimal cycle time value that will increase the production rate.

A literature survey was conducted by Otto and Battaia (2017) on reducing physical risks at assembly lines using line balancing methods and job rotation. They carried out an extensive overview of the existing optimisation approaches to production line balancing that consider physical ergonomic risks. The result showed that the ergonomic risks in production lines can be reduced significantly if they are taken into consideration during the planning stage of work assignment.

Sridhar *et al*. (2017) did a research on production line balancing in a Bearing industry to improve productivity. The study was conducted in an Indian company. The line was by firstly rearranging the existing tasks over the workstations and secondly by using Timer Pro professional software to group similar kinds of activities in other to get the most optimized productivity. Using both techniques, the result was an increase in the production of bearings. The number increased by 4,628 bearings employing the rearrangement technique and 55,770 bearings using the Timer Pro software.

Aung and Tun (2019) carried out a study on using Assembly line balancing to improve productivity using work sharing method. The purpose of the study was to balance the workloads on the assembly line stations while meeting the set goal of improving the production of women's pencil skirts. The study was done in Yangon, Myanmar. In balancing the line, they manually carried out the reduction of the idle and the cycle times, as well as the efficient distribution of the workloads through work sharing. Workers who have extra time on their hands after completing their tasks are made to take part in the bottleneck processes. This led to an increase in production from 260 pieces a day to 370 pieces.

Jirasirilerd *et al*. (2020) conducted a study on simple assembly line balancing problem type-2 by variable neighborhood strategy adaptive search. The study was conducted in Thailand, and the purpose of the study was to minimise the cycle time for a single assembly line so as to increase the production rate. A meta-heuristics, the Variable Neighborhood Strategy Adaptive Search (VaNSAS) method was used for computation. After testing with two groups of test instances, the results showed that the VaNSAS method outperformed LINGO 11, a software tool designed for solving optimisation problems. The tests led to a reduction in the cycle time and an increase in the production rate.

Edokpia and Owu (2023) carried out a study on the comparative analysis of assembly line re-balancing using ranked positional weight technique and the longest operation time technique. The study was conducted in Nigeria, and the purpose was to compare the efficiencies of applying two different heuristic algorithms to an assembly line of a company. The Ranked Positional Weight (RPW) technique and the Longest Operation Time (LOT) technique were the two heuristics employed. The results showed that LOT technique gave a higher line efficiency and lower number of workstations as compared to the RPW technique. The implication of this is that the LOT technique can give a better reduction in operational cost.

Great and Offiong (2023) conducted a study on productivity improvement in breweries through line balancing, using heuristic method. The purpose of the study was to balance the production line of Champion Lager Beer by minimising the number of workstations. The study was done in Nigeria. A heuristic method, the Longest Operation Time (LOT) technique was used in balancing the line. The result showed a reduction in idle time, an increase in the efficiency of the line as well as a reduction in the monthly production cost of the company.

Authors like Ikon and Nwankwo (2015), conducted a research on line balancing and performance of selected breweries in Anambra State, Nigeria. The purpose of the study was to reduce the idle time and the number of workstations so as to improve the performance of Life Beer and Hero Beer. The ranked Positional Weight (RPW) technique was the heuristic method employed in designing the new production lines for the companies. Primary data was collected for this research through observation of the time study top sheets. The results showed a decrease in labour cost of 1.3% for Hero Beer and 6.24% for Life Beer. The line efficiency was found to have increased by 18.9% for Hero Beer and 10% for Life Beer.

A study carried out at the Boulos Company Factory, Ogba industrial Estate in Lagos, Nigeria by Unuigbe *et al*. (2020) on assembly line balancing using artificial neural network in a tricycle assembly line showed a reduction in the standard cycle time from 576 seconds to 526 seconds. Also, the idle time was reduced from 105seconds to 56 seconds while the production output increased from 50 to 55 daily.

Another research study was carried out by Unuigbe *et al* (2021) on assembly line balancing using Fuzzy Logic in a Tricycle assembling company in Nigeria, the Boulos Enterprises Limited, located in Lagos State. The result obtained after using a computing based approach known as the Matrix Laboratory (MATLAB) fuzzy logic showed that the line efficiency increased by 4.3% while the total idle time decreased by 56.5%. Primary and secondary data were collected for the study using the time study top sheet.

Manaye (2019) carried out a study on line balancing technique for productivity improvement. The study was carried out in Ethiopia. The study was aimed out increasing the accuracy of standard time, minimising the number of workstations by proper tasks scheduling among the workers, and comparing the efficiencies and idle times of two balancing heuristics in a garment making company. The line balancing heuristics used were the Ranked Positional Weight (RPW) technique and the Largest Candidate Rule (LCR) technique. The results showed that after line balancing the number of workstations was reduced from 19 to 12, the actual daily output increased from 850 shirts to 1768 shirts and the line efficiency increased to 76.495 from 69.8. It also showed that the RPW technique gives better result when compared to the LCR technique.

Bagshaw (2020) did a study on work line balancing and production efficiency of manufacturing firms in Rivers State, Nigeria. The purpose of the study was to improve the production efficiency of the lines by reducing non-value added activities and the cycle times. Pearson's product moment correlation coefficient was used to test the significance of the relationship between the dimensions of work line balancing and production efficiency. One-piece flow and standardised work were used as proxy for work line balancing while product output, product quality and lead time reduction were used to proxy production efficiency. The result obtained showed that standardised work in workstations' tasks assignments give better work life balance and show a positive significant relationship with lead time reduction and product output. Again, the one-piece flow showed a more significant positive relationship with product quality than with lead time reduction and product output.

2.7 Research Gap

Looking at the directory of the Manufacturers Association of Nigeria (MAN), Edo State chapter, it is seen that there are forty eight (48) manufacturing companies currently registered with the association in Edo State. And many of these companies are Small and Medium Enterprises (SMEs), many of which struggle to stay in business. Even those that are able to manage these struggles have weak competitive positions with so many of their local and international counterparts because of high losses in terms of costs, time or quantity. Hence the need for waste reduction techniques, like one-piece flow, standardised work and a proper workplace ergonomics (Udeze, Ugbam & Ugwu, 2018).

From the conceptual, theoretical and empirical reviews, one can deduce that there is little discourse on how production line strategies affect the performance of manufacturing companies in Benin City. The available empirical studies on line balancing seem to focus on maximising the efficiency of the lines rather than their overall strategic benefits to the organisations (Wilson, 2024). Few of the researchers that wrote about performance in their works used only the financial measures of performance (Unuigbe *et al*., 2020; Aung & Tun, 2019; Ikon & Nwankwo, 2015).

In his research study, Bagshaw (2020) adopted product quality, product output and lead time reduction as proxy for production efficiency, but the study was done in Rivers State, Nigeria. None of these studies to the best of the researcher's knowledge has been conducted in the manufacturing companies in Benin City, Nigeria. And only a handful of them have combined both the financial and non-financial measures of performance in their studies. This is the gap in the studies. And this study attempts to fill this gap by examining the influence of production line strategies on operational performance of manufacturing firms in Benin City, Nigeria.

CHAPTER THREE

METHODOLOGY

3.1 Introduction

This chapter presents the research design, the population and sampling technique, sample size, research instrument, operationalisation and measurement of variables, validity and reliability of the research instrument, model specification, sources of data and lastly, the techniques of data analysis that was employed in this research work..

3.2 Research Design

This study employed the use of survey research design. This type of research allows the use of different methods of recruiting participants, gathering data, and utilizing various research instruments (Ponto, 2015). The choice of survey research design for this work is based on the fact that surveys can be used to collect first-hand information about the variables from respondents without the need for experimentation or observation.

3.3 Population of the Study

The target population of this study comprises the managerial staff of the 48 registered manufacturing companies in Benin City sourced from the directory of the Manufacturer's Association of Nigeria (MAN), Edo State chapter, as at February, 2022.

3.4 Sample Size and Sampling Technique

This study adopted judgmental and convenient sampling methods. A total of 144 managerial staff from the 48 manufacturing companies is the sample size. Three managers occupying key positions relating to productions and operations in each manufacturing company were selected. The key positions are Production Manager, Factory Supervisor and Assembly Supervisor. These three (3) positions were conveniently selected because the people occupying them are those mostly involved in managing activities in the factories where production lines are installed. Information regarding the operations and performance of the production/assembly lines can be sourced from them.

3.5 Model Specification

In this study, the model has operational performance as the dependent variable while one-piece flow, standardised work and ergonomic condition of the lines are the independent variables. Product output and product qualityare proxies for Operational performance. Each of them was shown as a function of one-piece flow, standardised work and ergonomic condition of the lines. This model is was adapted from the work of Bagshaw (2020).

The following show the econometric forms of the model.

Model 1:

$PDO = \alpha_0 + \alpha_1 OPF_i + \alpha_2 SDW_i + \alpha_3 ECL_i + e_i$ ………………………………… (1)

Model 2:

$PDQ = \beta_0 + \beta_1 OPFi + \beta_2 SDWi + \beta_3 ECL_i + e_i$ ………………………………… (2)

PDO	=	Product output
PDQ	=	Product quality
OPF	=	One-piece flow
SDW	=	Standardised work
ECL	=	Ergonomic Condition of the lines
e_i	=	Error term
α_0, β_0,	=	Parametric constants
α_1, α_2, α_3, β_1, β_2, β_3	=	Parametric coefficients of the independent variables

A-priori expectations:

$\alpha_1 > 0$: one-piece flow will result in an increase in product output.

$\alpha_2 > 0$: standardised work will lead to an increase in product output.

$\alpha_3 > 0$: A proper production line ergonomics will lead to an increase in product output.

$\beta_1 > 0$: One-piece flow will result in an improvement in product quality.

$\beta_2 > 0$: Standardised work will lead to an improvement in product quality.

$\beta_3 > 0$: A proper production line ergonomics will lead to an improved product quality.

3.6 Operationalisation of Variables

S/N	Variable	Operationalisation	Measurement	No. in Questionnaire
1	Independent Variable: OPF = One-piece Flow	A production system where items produced or processed are moved one unit at a time or a small batch at time from the first stage to the final stage without work-in-process (WIP) inventory (buffer) in between the stages.	5 point Likert scale	Q5-12
2	Independent Variable: SDW = Standardised work	The systematic determination and documentation of the steps of a job task and the sequence in which they should be performed	5 point Likert scale	Q13-23
3	Independent Variable: ECL = Ergonomic Condition of the Line	The arrangement of the workplace, products and systems in a way that optimizes the wellbeing of the workers as well as the performance of the organization.	5 point Likert scale	Q24-32
4	Dependent Variable: PDO = Product output	The quantity of goods produced in a specific time period.	5 point Likert scale	Q33-36
5	Dependent Variable: PDQ = Product quality	The quantity of goods produced in a specific time period.	5 point Likert scale	Q37-40

3.7 Sources of Data

The primary source of data was used in this research work. It involved the use of questionnaire as the research instrument.

3.8 Research Instrument

The questionnaire was used for the collection of data from the respondents under study. There are two parts to the questionnaire: part A and part B. Part A contains the demographic information, which involves the background and knowledge of the respondents. Refer to Appendix I. Part B was used to collect data on the dependent and independent variables. In part B, the respondents were required to indicate the extent to which they agreed or disagreed with the statements. The Likert 5 point scale was used on this part. The respondents were expected to respond in the following way: Strongly Disagree (1), Disagree (2), Undecided (3), Agree (4) and Strongly Agree (5). The numbers attached: 1, 2, 3, 4, 5 represented the weights for each of the scale measurement. Here, strongly agree has the highest ranking of 5 while strongly disagree has the lowest ranking of 1.

3.9 Validity and Reliability of the Research Instrument

To ensure the validity of the research instrument, a draft copy was sent to the supervisor to be reviewed and critiqued for clarity, appropriateness of language and instructions that the respondents are expected to adhere to. This aided in further modification and also ensures face and content validity of the instrument. Twenty (20) copies of the questionnaire were conveniently administered to a cross section of the respondents. The data gotten was coded and tested for reliability using the Cronbach's Alpha reliability test in Statistical Package for Social Sciences (SPSS). The result as presented in Table 3.2 below shows that the value for each construct is higher than 0.6, which implies the instrument is reliable for the study (Sekaran, 2003). Refer to Appendix III.

Table 3.2: Reliability Test

S/N	Variables	Number of Items	Cronbach's Alpha Value
1	One Piece Flow	9	0.603
2	Standardised Work	9	0.620
3	Ergonomic Condition of Lines	9	0.752
4	Operational Performance	12	0.738

Source: Researcher's fieldwork, 2025

3.10 Administration of the Questionnaire

For this research work, the questionnaire was administered manually and online. The Google form was used to administer it online, but where the Google form was not accessible to the respondents the copies of the questionnaire were administered manually. This means the researcher personally administered the questionnaire to the respondents while taking time to explain to them the grey areas that needed more light. After the copies of the questionnaire were filled by the respondents they were collected by the researcher for analysis.

3.11 Method of Data Analysis

Data was analysed using both descriptive and inferential statistical tools. The main statistical tool used is the Multiple Regression analyses, which is inferential. This was used in testing the hypotheses raised in chapter one of this work. The computation of the multiple regression analysis was used to investigate the degree of relationship, if any, that exists between the dependent variable and the independent variables. All evaluations was done using the Statistical Packages for Social Sciences (SPSS).

CHAPTER FOUR

DATA PRESENTATION, ANALYSIS AND INTERPRETATION

4.1 Introduction

This chapter focuses on the comprehensive presentation, analysis, and interpretation of the data gathered from the respondents. It meticulously encompasses the descriptive analysis, interpretation, and presentation of demographic information of the respondents, along with the data received on questions related to production line strategies and operational performance of manufacturing companies in Benin City. Furthermore, this chapter also includes the regression analysis and its interpretation concerning the hypothesized relationship between production line strategies and operational performance in manufacturing companies.

4.2 Description of Respondents' Socio-Demographics

This section contains a descriptive analysis of the demographic data drawn from the sampled respondents. The demographic variables include gender, age, work experience, marital status and department of the respondents.

Table 4.1: Socio-Demographic Characteristics of the Respondents

S/N	Categories	Frequency	
		No.	**%**
1.	**Gender**		
	Male	125	86.8
	Female	19	13.2
	Total	**144**	**100.0**
2.	**Education**		
	College Level	27	18.8
	Bachelor's Degree	93	64.6
	Master's Degree	20	13.9
	Doctoral Degree	4	2.8
	Total	**144**	**100.0**
3.	**Position in Organisation**		
	Production Manager	17	11.8
	Factory Supervisor	17	11.8
	Assembly Line Supervisor	110	76.4
	Total	**144**	**100.0**
4.	**Years of Experience**		
	1-5 years	70	48.6
	6-10 years	54	37.5
	11-15 years	20	13.9
	Total	**144**	**100.0**

Source: Field Survey, 2025.

Gender

Table 4.1 showed that majority of the respondents are male, comprising 86.8% of the sample, while females represent 13.2%. This indicates a significant gender disparity within the surveyed population, with males being substantially more represented than females.

Education

Regarding education level, the data in Table 4.1 revealed a diverse distribution among the respondents. The majority hold a Bachelor's degree (64.6%), followed by those with a College-level education (18.8%). Additionally, a considerable proportion has attained a Master's degree (13.9%), while a smaller percentage possesses a Doctoral degree (2.8%).

Position in Organization

Analysis of respondents' positions within their various organizations showcases a hierarchical distribution. The largest proportion of respondents holds the position of Assembly Line Supervisor (76.4%), indicating that this role is the most prevalent among the surveyed individuals. Meanwhile, Production Managers and Factory Supervisors each constitute 11.8% of the sample population, highlighting a relatively smaller representation in comparison.

Years of Experience

The data on respondents' years of experience as indicated in Table 4.1 provides insights into the respondents' years of experience. The majority of respondents have 1-5 years of experience (48.6%), followed by those with 6-10 years of experience (37.5%). A smaller proportion has 11-15 years of experience (13.9%), indicating a distribution skewed towards individuals with relatively less experience in the industry.

4.3 Description of Research Variables

The variables were described using simple percentage, mean and standard deviation. The independent variable is production line strategies while the dependent variable is operational performance.

4.3.1 Description of Production Line Strategies

In realizing this objective, first of all, the computed mean scores and standard deviation of responses to each factor of production line strategies which are assessed on a five-point Likert scale in which one represents a strong level of disagreement and five represents a strong level of agreement are presented below.

Table 4.2 below showed the description of production line strategies in the manufacturing industry in Benn City, Edo State.

Table 4.2: Description of Production Line Strategies

Q/N	Item	Frequency							Decision Rule: <3 Reject >3 Accept
		1	2	3	4	5	Mean	SD	
	ONE-PIECE FLOW								
5	Cuts down wastages in terms of cost and space	22	-	-	87	35	3.78	1.258	**Accepted**
6	Increases production processing times	29	43	5	53	14	2.86	1.362	**Rejected**
7	Increases quantity produced	4	18	5	40	77	4.17	1.14	**Accepted**
8	Boosts workers' morale	-	33	59	33	19	3.26	0.961	**Accepted**
9	Makes product defects easy to spot	4	5	4	72	59	4.23	0.883	**Accepted**
10	Reduces the quality of products	15	73	14	9	33	2.81	1.37	**Rejected**
11	Eliminates bottlenecks in the production process	6	9	11	53	65	4.13	1.07	**Accepted**
12	Allows for workers' innovativeness	-	25	25	56	38	3.74	1.036	**Accepted**
13	Causes the work to be monotonous	9	16	46	59	14	3.37	1.016	**Accepted**
	Average Total						**3.594444**	**1.21778**	**Accepted**
	STANDARDISED WORK								
14	Work standardization helps the organisation reduce product defects	12	3	12	105	12	3.71	0.96	**Accepted**
15	The use of standardised work improves workers' productivity	-	10	16	102	16	3.86	0.696	**Accepted**
16	The organisation finds it easy to meet customers' demands when works are standardised	-	8	7	124	5	3.88	0.54	**Accepted**

17	Adopting work standardization allows workers to easily identify areas that need improvement	3	-	14	102	25	4.01	0.679	**Accepted**
18	It reduces jobs processing times when organisations adopt work standardization	-	29	10	86	19	3.66	0.947	**Accepted**
19	Using work standardization lowers the quality of items produced.	47	38	20	34	5	2.39	1.258	**Rejected**
20	By giving employees the ability to identify possible improvement areas, standardised work helps them develop a sense of ownership and competency in their careers.	4	18	15	82	25	3.74	0.982	**Accepted**
21	It makes the jobs to be monotonous	8	14	16	96	10	3.6	0.956	**Accepted**
22	Standardised work elicits zero workers initiatives.	8	23	11	97	5	3.47	0.989	**Accepted**
	Average Total						**3.591111**	**0.889667**	**Accepted**
	WORK PLACE ERGONOMICS								
23	Successful implementation of workplace ergonomics on a production line makes the workers to be more focused on their jobs	9	6	15	31	83	4.2	1.174	**Accepted**
24	It brings about improved workers' productivity	5	17	25	69	28	3.68	1.029	**Accepted**
25	Work place ergonomics increases production efficiency	2	7	3	126	6	3.88	0.609	**Accepted**
26	Product quality is positively affected	3	6	20	89	26	3.9	0.817	**Accepted**

	because workers are more focused on their jobs.								
27	Increases workers involvement in the production process	7	8	8	104	17	3.81	0.895	**Accepted**
28	It increases the number of workers turnover rate	28	101	3	7	5	2.03	0.852	**Rejected**
29	Brings about unhappy employees	25	77	15	10	17	2.42	1.204	**Rejected**
30	Fewer work injuries saves cost for the organisation	2	7	3	9	123	4.69	0.847	**Accepted**
31	Reduces workers absenteeism	5	16	95	25	3	3.03	0.714	**Accepted**
	Average Total						**3.515556**	**0.904556**	**Accepted**
	Overall Production Line Strategies Score						**3.567037**	**1.004001**	**Accepted**

Source: Field Survey, 2025.

N.B: **1, 2, 3, 4 and 5 denote strongly disagreed, disagreed, undecided, agreed, strongly agreed response rate respectively.**

The above provided table 4.2 presents the description of production line strategies based on various items related to one-piece flow, standardised work and ergonomic conditions of a production line. The analysis uses a decision rule where a mean score of <3 is rejected, and >3 is accepted.

One Piece Flow

From table 4.2 above, based on the provided survey data, one-piece flow strategies and their implications for operational performance in manufacturing companies in Benin City was analysed and the following analysis can be drawn. “Cuts down wastages in terms of cost and space” (Statement 5): 22 respondents disagreed, 87 agreed, and 35 strongly agreed that one-piece flow cuts down wastages in terms of cost and space. The mean response was 3.78, indicating a generally positive perception of this aspect of one-piece flow. “Increases production processing times” (Statement 6):29 respondents strongly disagreed, 43 disagreed, 5 were undecided, 53 agreed, and 14 strongly agreed that one-piece flow increases production processing times.The mean response was 2.86, suggesting a mixed perception with a tendency towards disagreement.“Increases quantity produced (Statement 7): 4 respondents strongly disagreed, 18 disagreed, 5 were undecided, 40 agreed, and 77 strongly agreed that one-piece flow increases quantity produced.The mean response was 4.17, indicating a strong positive perception regarding this aspect. “Boosts workers’ morale” (Statement 8):33 respondents disagreed, 59 were undecided, 33 agreed, and 19 strongly agreed that one-piece flow boosts workers’ morale.The mean response was 3.26, suggesting a neutral to slightly positive perception. “Makes product defects easy to spot” (Statement 9): 4 respondents strongly disagreed, 5 disagreed, 4 were undecided, 72 agreed, and 59 strongly agreed that one-piece flow makes product defects easy to spot.The mean response was 4.23, indicating a strong positive perception. “Reduces the quality of products” (Statement 10):15 respondents strongly disagreed, 73 disagreed, 14 were undecided, 9 agreed, and 33 strongly agreed that one-piece flow reduces the quality of products.The mean response was 2.81, suggesting a moderate to strong disagreement with this statement. “Eliminates bottlenecks in the production process” (Statement 11):6 respondents strongly disagreed, 9 disagreed, 11 were undecided, 53 agreed, and 65 strongly agreed that one-piece flow eliminates bottlenecks in the production process.The mean response was 4.13, indicating a strong positive perception. “Allows for workers’ innovativeness” (Statement 12):25 respondents disagreed, 25 were undecided, 56 agreed, and 38 strongly agreed that one-piece flow allows for workers’ innovativeness. The mean response was 3.74, suggesting a moderately positive perception. “Causes the work to be monotonous” (Statement 13): 9 respondents strongly disagreed, 16 disagreed, 46 were undecided, 59 agreed, and 14 strongly agreed that one-piece flow causes the work to be monotonous. The mean response was 3.37, indicating a moderate level of agreement. Overall, the average mean response across all statements related to one-piece flow was 3.594, with a standard deviation of 1.218, suggesting moderate to positive perceptions overall.

Standardised Work

Also, from table 4.2 above, based on the provided survey data, standardised work strategies and their implications for operational performance was analysed and the following analysis can be drawn. Work standardization helps the organization reduce product defects (Statement 14):12 respondents strongly disagreed, 3 disagreed, 12 were undecided, 105 agreed, and 12 strongly agreed that work standardization helps reduce product defects.The mean response was 3.71, indicating a moderately positive perception. The use of standardised work improves workers’ productivity (Statement 15):10 respondents disagreed, 16 were undecided, 102 agreed, and 16 strongly agreed that the use of standardised work improves workers’ productivity. The mean response was 3.86, indicating a generally positive perception. The organization finds it easy to meet customers’ demands when works are standardised (Statement 16):8 respondents disagreed, 7 were undecided, 124 agreed, and 5 strongly agreed that the organization finds it easy to meet customers’ demands when works are standardised. The mean response was 3.88, indicating a strong positive perception. Adopting work standardization allows workers to easily identify areas that need improvement (Statement 17):3 respondents strongly disagreed, 14 were undecided, 102 agreed, and 25 strongly agreed that adopting work standardization allows workers to easily identify areas that need improvement. The mean response was 4.01, indicating a strong positive perception.It reduces job processing times when organizations adopt work standardization (Statement 18):29 respondents disagreed, 10 were undecided, 86 agreed, and 19 strongly agreed that it reduces job processing times when organizations adopt work standardization. The mean response was 3.66, indicating a moderately positive perception. Using work standardization lowers the quality of items produced (Statement 19):47 respondents strongly disagreed, 38 disagreed, 20 were undecided, 34 agreed, and 5 strongly agreed that using work standardization lowers the quality of items produced. The mean response was 2.39, indicating a moderate level of disagreement.By giving employees the ability to identify possible improvement areas, standardised work helps them develop a sense of ownership and competency in their careers (Statement 20):4 respondents strongly disagreed, 18 disagreed, 15 were undecided, 82 agreed, and 25 strongly agreed with this statement. The mean response was 3.74, indicating a moderately positive perception. It makes the jobs to be monotonous (Statement 21):8 respondents strongly disagreed, 14 disagreed, 16 were undecided, 96 agreed, and 10 strongly agreed that standardised work makes the jobs monotonous. The mean response was 3.6, indicating a moderate level of agreement. Standardised work elicits zero workers initiatives (Statement 22):8 respondents strongly disagreed, 23 disagreed, 11 were undecided, 97 agreed, and 5 strongly agreed with this statement. The mean response was 3.47, indicating a moderately positive perception. Overall, the average mean response across all statements related to standardised work was 3.591, with a standard deviation of 0.890, suggesting moderate to positive perceptions overall.

Ergonomic Condition of the Lines

From table 4.2 above, based on the provided survey data, ergonomic condition of the lines and its impact on operational performance was analysed and the following analysis can be drawn. Successful implementation of workplace ergonomics on a production line makes the workers more focused on their jobs (Statement 23):9 respondents strongly disagreed, 6 disagreed, 15 were undecided, 31 agreed, and 83 strongly agreed with this statement. The mean response was 4.2, indicating a strong positive perception.It brings about improved workers' productivity (Statement 24):5 respondents strongly disagreed, 17 disagreed, 25 were undecided, 69 agreed, and 28 strongly agreed with this statement. The mean response was 3.68, indicating a moderately positive perception. Workplace ergonomics increases production efficiency (Statement 25):2 respondents strongly disagreed, 7 disagreed, 3 were undecided, 126 agreed, and 6 strongly agreed with this statement.The mean response was 3.88, indicating a strong positive perception. Product quality is positively affected because workers are more focused on their jobs (Statement 26): 3 respondents strongly disagreed, 6 disagreed, 20 were undecided, 89 agreed, and 26 strongly agreed with this statement. The mean response was 3.9, indicating a strong positive perception.“Increases workers' involvement in the production process” (Statement 27):7 respondents strongly disagreed, 8 disagreed, 8 were undecided, 104 agreed, and 17 strongly agreed with this statement. The mean response was 3.81, indicating a strong positive perception. It increases the number of workers' turnover rate (Statement 28):28 respondents strongly disagreed, 101 disagreed, 3 were undecided, 7 agreed, and 5 strongly agreed with this statement. The mean response was 2.03, indicating a strong disagreement. “Brings about unhappy employees” (Statement 29):25 respondents strongly disagreed, 77 disagreed, 15 were undecided, 10 agreed, and 17 strongly agreed with this statement. The mean response was 2.42, indicating a moderate level of disagreement. Fewer work injuries save cost for the organization (Statement 30):2 respondents strongly disagreed, 7 disagreed, 3 were undecided, 9 agreed, and 123 strongly agreed with this statement. The mean response was 4.69, indicating a strong positive perception. Reduces workers' absenteeism (Statement 31):5 respondents strongly disagreed, 16 disagreed, 95 were undecided, 25 agreed, and 3 strongly agreed with this statement. The mean response was 3.03, indicating a moderate level of agreement. Overall, the average mean response across all statements related to workplace ergonomics was 3.516, with a standard deviation of 0.905, suggesting moderate to positive perceptions overall.

The overall Production Line Strategies score is 3.567, with a standard deviation of approximately 1.004. This indicates that, on average, respondents tend to agree with statements related to production line strategies, but there is a notable degree of variability in their responses.A mean score above 3 suggests that, overall, respondents lean towards agreement with the statements regarding production line strategies. This indicates a positive perception or experience with these strategies among the respondents.However, the relatively high standard deviation of around 1.004 suggests that there is significant variability in respondents' opinions or experiences regarding production line strategies. Some respondents may strongly agree with these strategies, while others may strongly disagree, resulting in a wide range of responses.

4.3.2 Description of Operational Performance

Table 4.3 showed the description of Operational Performance in the manufacturing industry in Benin City, Edo State.

Table 4.3 Description of Operational Performance

Q/N	Item	Frequency							Decision Rule: <3 Reject >3 Accept
		1	2	3	4	5	Mean	SD	
	OPERATIONAL PERFORMANCE								
	Product Output								
32	Production rate has increased this period.	2	7	-	112	23	4.02	0.694	**Accepted**
33	There is a reduction in customers' lead-time this period.	-	15	9	120	-	3.73	0.639	
34	Cost of production has increased significantly	33	54	29	15	13	2.45	1.211	**Rejected**
35	Quantity produced has decreased greatly this period.	-	105	19	15	5	2.44	0.817	**Rejected**
	Total						**3.16**	**0.84025**	**Accepted**
	Product Quality								
36	Product defects have reduced significantly this period.	9	5	4	43	83	4.29	1.109	**Accepted**
37	There is zero customer complaint about our products this season.	-	29	24	72	19	3.56	0.959	
38	Our products are positively rated this period.	9	9	13	90	23	3.76	1.005	**Accepted**
39	Customer demands for our products have decreased significantly over time.	15	86	20	16	7	2.4	0.985	**Rejected**
	Total						**3.5025**	**1.0145**	**Accepted**
	Overall Operational Performance Score						**3.33125**	**0.92735**	**Accepted**

Source: Field Survey, 2025.

***N.B:* 1, 2, 3, 4 and 5 denote strongly disagreed, disagreed, undecided, agreed, strongly agreed response rate respectively**

Operational Performance

From table 4.3 above, a detailed overview of the operational performance in the manufacturing industry in Benin City, Edo State can be seen.

Product Output

The data provided were analysed with respect to various aspects of product output. For, production rate increase (statement 32), 2 respondents strongly disagreed, 7 disagreed, no respondents were undecided, 112 respondents agreed, and 23 respondents strongly agreed. The mean response was 4.02 with a standard deviation of 0.694. Similarly, for reduction in customers' lead-time (statement 33), 15 respondents disagreed, 9 were undecided, and 120 agreed. The mean response was 3.73 with a standard deviation of 0.639. Again, as regards respondents' responses to significant increase in cost of production (statement 34), 33 respondents strongly disagreed, 54 disagreed, 29 were undecided, 15 agreed and 13 strongly agreed. The mean response was 2.45 with a standard deviation of 1.211. Finally, as regards great decrease in quantity produced (statement 35), 105 respondents disagreed, 19 were undecided, 15 agreed while 5 strongly agreed to this statement. The mean response was 2.44 with a standard deviation of 0.817. The overall mean for the four questions was 3.16 with a standard deviation of 0.84025 indicating that product output is significant for operational performance.

Product Quality

For Product Quality analysis, the provided data was examined concerning various indicators of product quality. Beginning with the statement on the significant reduction in product defects (statement 36), the responses were as follows: 9 respondents strongly disagreed, 5 disagreed, 4 were undecided, 43 agreed, and 83 strongly agreed. The mean response for this statement was 4.29, with a standard deviation of 1.109. Regarding customer complaints about products (statement 37), 29 respondents disagreed, 24 were undecided, 72 agreed, and 19 strongly agreed. The mean response for this statement was 3.56, with a standard deviation of 0.959. Next, for the statement concerning positive ratings for products (statement 38), 9 respondents strongly disagreed, 9 disagreed, 13 were undecided, 90 agreed, and 23 strongly agreed. The mean response was 3.76, with a standard deviation of 1.005. Lastly, for the reduction in customer demands (statement 39), 15 respondents strongly disagreed, 86 disagreed, 20 were undecided, 16 agreed, and 7 strongly agreed. The mean response was 2.4, with a standard deviation of 0.985. The overall mean for the four statements was calculated to be 3.5025, with a standard deviation of 1.0145, indicating the significance of product quality on operational performance.

For the overall assessment of operational performance, the total mean score was calculated to be 3.33125, with a standard deviation of 0.92735. This metric encompasses various dimensions, including aspects related to product output, and product quality. The mean score above the midpoint of 3 indicates a generally positive perception of operational performance among the respondents. However, the standard deviation suggests some variability in the responses, indicating that while the overall performance is perceived positively on average, there may be some divergence in individual opinions.

4.4 Estimation and Interpretation of Model/Relationship between Production Line Strategies and Operational Performance in the Manufacturing Industry, Benin City, Edo State, Nigeria.

4.4.1 Correlation Analysis

Bivariate Pearson correlation coefficients were conducted on the data for all the variables in the study. Table 4.4.1 shows the Pearson correlation coefficients among research variables.

Table 4.4.1a: Pearson Correlation Coefficients among Research Variables using Operational Performance

Variable		OrgPerf	OPF	SDW	ECL
Operational Performance (OrgPerf)	Pearson Correlation	1	.585**	.700**	.734**
	Sig. (2-tailed)		.000	.000	.000
	N	144	144	144	144
One Piece Flow	Pearson Correlation	.585**	1	.699**	.465**
	Sig. (2-tailed)	.000		.000	.000
	N	144	144	144	144
Standardised Work	Pearson Correlation	.700**	.699**	1	.766**
	Sig. (2-tailed)	.000	.000		.000
	N	144	144	144	144
Workplace Ergonomics	Pearson Correlation	.734**	.465**	.766**	1
	Sig. (2-tailed)	.000	.000	.000	
	N	144	144	144	144

**. Correlation is significant at the 0.01 level (2-tailed).

Table 4.4.1ashows the correlation analysis conducted with the aim of exploring the relationships between the variables under study. Bivariate Pearson correlation coefficients were computed to assess the degree and direction of association among the research variables, including Operational Performance (OrgPerf), One Piece Flow (OPF), Standardised Work (SDW), and Workplace Ergonomics (ECL).The Pearson correlation coefficients reveal statistically significant positive correlations between Operational Performance and all other variables in the study. Specifically, there is a strong positive correlation between Operational Performance and Standardised Work ($r = 0.700$, $p < 0.01$) as well as Workplace Ergonomics ($r = 0.734$, $p < 0.01$). Additionally, a moderately strong positive correlation exists between Operational Performance and One Piece Flow ($r = 0.585$, $p < 0.01$).The analysis indicates significant positive correlations between One Piece Flow and the other variables in the study. Notably, One Piece Flow exhibits a strong positive correlation with Standardised Work ($r = 0.699$, $p < 0.01$) and Workplace Ergonomics ($r = 0.465$, $p < 0.01$). Similar to One Piece Flow, Standardised Work demonstrates significant positive correlations with Operational Performance, One Piece Flow, and Workplace Ergonomics. Particularly noteworthy is the strong positive correlation between Standardised Work and Workplace Ergonomics ($r = 0.766$, $p < 0.01$).Lastly, Workplace Ergonomics displays significant positive correlations with all other variables in the study. Notably, it exhibits strong positive correlations with Operational Performance ($r = 0.734$, $p < 0.01$) and Standardised Work ($r = 0.766$, $p < 0.01$).

Table 4.4.1b: Pearson Correlation Coefficients among Research Variables using Product Output

Variable		PDO	OPF	SDW	ECL
Product Output (PDO)	Pearson Correlation	1	.373**	.572**	.781**
	Sig. (2-tailed)		.000	.000	.000
	N	144	144	144	144
One Piece Flow	Pearson Correlation	.373**	1	.699**	.465**
	Sig. (2-tailed)	.000		.000	.000
	N	144	144	144	144
Standardised Work	Pearson Correlation	.572**	.699**	1	.766**
	Sig. (2-tailed)	.000	.000		.000
	N	144	144	144	144
Workplace Ergonomics	Pearson Correlation	.781**	.465**	.766**	1
	Sig. (2-tailed)	.000	.000	.000	
	N	144	144	144	144

**. Correlation is significant at the 0.01 level (2-tailed).

Table 4.4.1b presents the Pearson correlation coefficients among the research variables using Product Output as one of the dependent variables. The correlation analysis indicates statistically significant positive correlations between Product Output and all other variables in the study. Notably, there is a strong positive correlation between Product Output and Workplace Ergonomics ($r = 0.781$, $p < 0.01$), suggesting that higher levels of workplace ergonomics are associated with increased product output. Additionally, Product Output shows moderate positive correlations with Standardised Work ($r = 0.572$, $p < 0.01$) and One Piece Flow ($r = 0.373$, $p < 0.01$), indicating that improvements in these production line strategies are positively associated with higher product output. Similarly, One Piece Flow exhibits significant positive correlations with all other variables in the study. Notably, it demonstrates a strong positive correlation with Standardised Work ($r = 0.699$, $p < 0.01$) and moderate positive correlation with Workplace Ergonomics ($r = 0.465$, $p < 0.01$). The analysis reveals significant positive correlations between Standardised Work and all other variables. Notably, it shows strong positive correlations with Workplace Ergonomics ($r = 0.766$, $p < 0.01$) and moderate positive correlation with Product Output ($r = 0.572$, $p < 0.01$).Lastly, Workplace Ergonomics displays significant positive correlations with all other variables. It exhibits a strong positive correlation with Product Output ($r = 0.781$, $p < 0.01$) and Standardised Work ($r = 0.766$, $p < 0.01$), indicating that higher levels of workplace ergonomics are associated with improved product output and standardised work strategies.

Table 4.4.1c: Pearson Correlation Coefficients among Research Variables using Product Quality

Variable		PDQ	OPF	SDW	ECL
Product Quality (PDQ)	Pearson Correlation	1	.644**	.675**	.572**
	Sig. (2-tailed)		.000	.000	.000
	N	144	144	144	144
One Piece Flow	Pearson Correlation	.644**	1	.699**	.465**
	Sig. (2-tailed)	.000		.000	.000
	N	144	144	144	144
Standardised Work	Pearson Correlation	.675**	.699**	1	.766**
	Sig. (2-tailed)	.000	.000		.000
	N	144	144	144	144
Workplace Ergonomics	Pearson Correlation	.572**	.465**	.766**	1
	Sig. (2-tailed)	.000	.000	.000	
	N	144	144	144	144

**. Correlation is significant at the 0.01 level (2-tailed).

Table 4.4.1cpresents the Pearson correlation coefficients among the research variables using Product Quality (PDQ) as one of the dependent variables. The correlation analysis reveals statistically significant positive correlations between Product Quality and all other variables in the study. Notably, there is a strong positive correlation between Product Quality and both Standardised Work ($r = 0.675$, $p < 0.01$) and One Piece Flow ($r = 0.644$, $p < 0.01$), suggesting that improvements in these production line strategies are associated with higher product quality. Additionally, Product Quality shows a moderate positive correlation with Workplace Ergonomics ($r = 0.572$, $p < 0.01$), indicating that enhanced ergonomic conditions are also positively related to better product quality. Similarly, One Piece Flow exhibits significant positive correlations with all other variables in the study. Notably, it demonstrates strong positive correlations with both Product Quality ($r = 0.644$, $p < 0.01$) and Standardised Work ($r = 0.699$, $p < 0.01$), indicating that improvements in one-piece flow strategies are associated with higher product quality and standardised work strategies. The analysis reveals significant positive correlations between Standardised Work and all other variables. Notably, it shows strong positive correlations with Product Quality ($r = 0.675$, $p < 0.01$) and One Piece Flow ($r = 0.699$, $p < 0.01$), indicating that improvements in standardised work strategies are associated with better product quality and one-piece flow. Lastly, Workplace Ergonomics displays significant positive correlations with all other variables. It exhibits a moderate positive correlation with Product Quality ($r = 0.572$, $p < 0.01$) and a strong positive correlation with Standardised Work ($r = 0.766$, $p < 0.01$), suggesting that improvements in workplace ergonomics are positively associated with better product quality and standardised work strategies.

4.4.2 Results of Regression Analysis

The regression analysis was performed to start a relationship between production line strategies and operational performance of manufacturing companies in Benin City, Edo State. Below are tables representing the output of the regression analysis.

Table 4.5a: Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	.786[a]	.619	.610	2.74354	1.183

a. Predictors: (Constant), Workplace Ergonomics, One Piece Flow, Standardised Work
b. Dependent Variable: Operational Performance

The coefficient of determination (R^2) is reported at 0.619, indicating that 61.9 percent of the systematic variations in the dependent variable (Operational Performance) are explained by the independent variables (Workplace Ergonomics, One Piece Flow, and Standardised Work) in this model. Furthermore, the adjusted coefficient of determination (Adjusted R^2) is recorded at 0.610, suggesting that the data adequately fits the model. The standard error of the estimate is reported as 2.74354, providing an indication of the variability around the regression line. Additionally, the Durbin-Watson statistic is presented with a value of 1.183. As it is less than 2, there is evidence of positive autocorrelation, suggesting that successive error terms are positively correlated.

Table 4.5b: Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	.784[a]	.614	.606	1.31618	1.445

a. Predictors: (Constant), Workplace Ergonomics, One Piece Flow, Standardised Work
b. Dependent Variable: Product Output

The coefficient of determination (R^2) is reported at 0.614, indicating that 61.4 percent of the systematic variations in the dependent variable (Product Output) are explained by the independent variables (Workplace Ergonomics, One Piece Flow, and Standardised Work) in this model. Additionally, the adjusted coefficient of determination (Adjusted R^2) stands at 0.606, suggesting that the data fits the model reasonably well. The standard error of the estimate is recorded as 1.31618, providing an indication of the variability around the regression line.

Furthermore, the Durbin-Watson statistic is presented with a value of 1.445. As it is close to 2, there is no clear evidence of autocorrelation, indicating that successive error terms may not be significantly correlated.

Table 4.5c: Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	.728[a]	.529	.519	1.92666	1.539

a. Predictors: (Constant), Workplace Ergonomics, One Piece Flow, Standardised Work
b. Dependent Variable: Product Quality

The coefficient of determination (R^2) is reported at 0.529, indicating that 52.9 percent of the systematic variations in the dependent variable (Product Quality) are explained by the independent variables (Workplace Ergonomics, One Piece Flow, and Standardised Work) in this model. The adjusted coefficient of determination (Adjusted R^2) is slightly lower at 0.519, suggesting that the model fits the data adequately. The standard error of the estimate is recorded as 1.92666, providing an indication of the variability around the regression line. Additionally, the Durbin-Watson statistic is presented with a value of 1.539. As it is close to 2, there is no clear evidence of autocorrelation, indicating that successive error terms may not be significantly correlated.

Table 4.6a: ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	1708.544	3	569.515	75.663	.000[b]
	Residual	1053.782	140	7.527		
	Total	2762.326	143			

a. Dependent Variable: Operational Performance
b. Predictors: (Constant), Workplace Ergonomics, One Piece Flow, Standardised Work

From Table 4.6a above, the analysis of variance (ANOVA) results indicates a significant relationship between the predictors (Workplace Ergonomics, One Piece Flow, and Standardised Work) and the dependent variable (Operational Performance) within manufacturing companies in Benin City, Edo State. The ANOVA table provides insights into the contribution of the regression model in explaining the variance in Operational Performance. The sum of squares for Regression is reported as 1708.544, indicating the total variation in Operational Performance explained by the predictors. Contrastingly, the Residual sum of squares is 1053.782, representing the unexplained variation or error in the model. The F-statistic, calculated as 75.663, is associated with a p-value (Sig.) of

.000, which is less than the conventional significance level of 0.05. This indicates that the regression model as a whole is statistically significant in predicting Operational Performance. In other words, there is strong evidence to suggest that at least one of the predictors (Workplace Ergonomics, One Piece Flow, and Standardised Work) has a significant effect on Operational Performance.

Table 4.6b: ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	386.411	3	128.804	74.353	.000[b]
	Residual	242.527	140	1.732		
	Total	628.938	143			

a. Dependent Variable: Product Output
b. Predictors: (Constant), Workplace Ergonomics, One Piece Flow, Standardised Work

From Table 4.6b, the analysis of variance (ANOVA) results indicates a significant relationship between the predictors (Workplace Ergonomics, One Piece Flow, and Standardised Work) and the dependent variable (Product Output) within manufacturing companies in Benin City, Edo State. The ANOVA table provides insights into the contribution of the regression model in explaining the variance in Product Output. The sum of squares for Regression is reported as 386.411, indicating the total variation in Product Output explained by the predictors. Contrastingly, the Residual sum of squares is 242.527, representing the unexplained variation or error in the model. The F-statistic, calculated as 74.353, is associated with a p-value (Sig.) of .000, which is less than the conventional significance level of 0.05. This indicates that the regression model as a whole is statistically significant in predicting Product Output. In other words, there is strong evidence to suggest that at least one of the predictors (Workplace Ergonomics, One Piece Flow, and Standardised Work) has a significant effect on Product Output.

Table 4.6c: ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	584.288	3	194.763	52.468	.000[b]
	Residual	519.684	140	3.712		
	Total	1103.972	143			

a. Dependent Variable: Product Quality
b. Predictors: (Constant), Workplace Ergonomics, One Piece Flow, Standardised Work

From Table 4.6c, the analysis of variance (ANOVA) results indicates a significant relationship between the predictors (Workplace Ergonomics, One Piece Flow, and Standardised Work) and the dependent variable (Product Quality) within manufacturing companies in Benin City, Edo State. The ANOVA table provides insights into the contribution of the regression model in explaining the variance in Product Quality. The sum of squares for Regression is reported as 584.288, indicating the total variation in Product Quality explained by the predictors. Contrastingly, the Residual sum of squares is 519.684, representing the unexplained variation or error in the model. The F-statistic, calculated as 52.468, is associated with a p-value (Sig.) of .000, which is less than the conventional significance level of 0.05. This indicates that the regression model as a whole is statistically significant in predicting Product Quality. In other words, there is strong evidence to suggest that at least one of the predictors (Workplace Ergonomics, One Piece Flow, and Standardised Work) has a significant effect on Product Quality.

4.5 Test of Hypotheses

The hypotheses were tested with a p-value in the regression result. Where the p-values are greater than or equal to 0.05, the null hypotheses (H_0) are not rejected. And where the p-values are less than 0.05, the null hypotheses (H_0) are dismissed. The results of the interpretations presented below.

Table 4.7a: Coefficients[a]

Model		Unstandardised Coefficients		Standardised Coefficients		
		B	Std. Error	Beta	t	Sig.
1	(Constant)	3.809	1.563		2.436	0.016
	One Piece Flow	0.179	0.051	0.260	3.517	0.001
	Standardised Work	0.103	0.090	0.117	1.147	0.254
	Ergonomic Condition of the Line	0.434	0.068	0.524	6.370	0.000

a. Dependent Variable: Operational Performance

Table 4.7b: Coefficients[a]

Model		Unstandardised Coefficients		Standardised Coefficients		
		B	Std. Error	Beta	t	Sig.
1	(Constant)	3.043	0.750		4.057	0.000
	One Piece Flow	0.021	0.024	0.063	0.848	0.398
	Standardised Work	-0.049	0.043	-0.117	-1.146	0.254
	Ergonomic Condition of the Line	0.333	0.033	0.842	10.184	0.000

a. Dependent Variable: Product Output

Table 4.7c: Coefficients[a]

Model		Unstandardised Coefficients		Standardised Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	0.766	1.098		0.698	0.486
	One Piece Flow	0.158	0.036	0.364	4.428	0.000
	Standardised Work	0.152	0.063	0.273	2.416	0.017
	Ergonomic Condition of the Line	0.101	0.048	0.193	2.113	0.036

a. Dependent Variable: Product Quality

Hypothesis 1

H_{01}: There is no significant relationship between one-piece flow and operational performance.

Table 4.7a,b and c above showed the regression coefficients, t and P-value corresponding to the effect of one piece flow and operational performance of manufacturing companies in Benin City, Edo State. For Product Output, the coefficient for One Piece Flow is 0.021 ($p = 0.398$). This coefficient indicates that there is no significant relationship between One Piece Flow and Product Output. We fail to reject the null hypothesis as there is no significant relationship between one-piece flow and product output. On the other hand, for Product Quality, the coefficient for One Piece Flow is 0.158 ($p = 0.000$). This coefficient indicates a significant positive relationship between One Piece Flow and Product Quality. We therefore reject the null hypothesis as there is a significant positive relationship between one-piece flow and product quality. Overall, for Operational

Performance, the coefficient for One Piece Flow is 0.179 (p = 0.001). This coefficient indicates a significant positive relationship between One Piece Flow and Operational Performance. We therefore reject the null hypothesis as there is a significant positive relationship between one-piece flow and operational performance.

Hypothesis 2

H_{02}: There is no significant relationship between standardised work and operational performance.

Table 4.7a,b and c above showed the regression coefficients, t and P-value corresponding to the effect of standardised work and operational performance of manufacturing companies in Benin City, Edo State. For Product Output, the coefficient for Standardised Work is -0.049 (p = 0.254). This coefficient indicates that there is no significant relationship between Standardised Work and Product Output. We therefore fail to reject the null hypothesis as there is no significant relationship between standardised work and product output. On the other hand, for Product Quality, the coefficient for Standardised Work is 0.152 (p = 0.017).This coefficient indicates a significant positive relationship between Standardised Work and Product Quality. We therefore reject the null hypothesis as there is a significant positive relationship between standardised work and product quality. Overall, for Operational Performance, the coefficient for Standardised Work is 0.103 (p = 0.254).This coefficient indicates that there is no significant relationship between Standardised Work and Operational

Performance. We therefore fail to reject the null hypothesis as there is no significant relationship between standardised work and operational performance.

Hypothesis 3

H_{03}: There is no significant relationship between the ergonomic conditions of a production line and operational performance.

Table 4.7a,b and c above showed the regression coefficients, t and P-value corresponding to the effect of ergonomic conditions and operational performance of manufacturing companies in Benin City, Edo State. For Product Output, the coefficient for Ergonomic Condition of the Line is 0.333 (p = 0.000). This coefficient indicates a significant positive relationship between Ergonomic Condition of the Line and Product Output. We therefore reject the null hypothesis as there is a significant positive relationship between the ergonomic conditions of a production line and product output. On the other hand, for Product Quality, the coefficient for One Piece Flow is 0.158 (p = 0.000).This coefficient indicates a significant positive relationship between One Piece Flow and Product Quality. We therefore reject the null hypothesis as there is a significant positive relationship between one-piece flow and product quality. Overall, for Operational Performance, the coefficient for Ergonomic Condition of the Line is 0.434 (p = 0.000).This coefficient indicates a significant positive relationship between Ergonomic Condition of the Line and Operational Performance. We therefore reject the null hypothesis as there is a significant positive relationship between the ergonomic conditions of a production line and operational performance.

4.6 Discussion of Findings

This study examined the impact of production line strategies on the operational performance of manufacturing companies in Benin City, Edo State. Copies of the structured questionnaire were distributed to the sampled respondents who are employees of the manufacturing organisations under examination.

Based on the analysis conducted, the analysis showed no significant relationship between one-piece flow and product output, which aligns with the findings of Otto and Battaia (2017) and Polat *et al*. (2018). However, there was a significant positive relationship between one-piece flow and product quality, which contradicts the findings of Edokpia and Owu (2023) and Manaye (2019). Overall, the results revealed a significant positive relationship between one-piece flow and operational performance, corroborating the findings of Chutima and Suphapruksaspongse (2004) and Akhter *et al*. (2016).This goes to show from the above that manufacturing companies in Benin City, Edo State should implement one-piece flow and standardised work strategies to serve as effective operational strategies for enhancing product quality. By adopting one-piece flow, companies can streamline their production processes, reduce waste, and improve overall efficiency. Standardised work strategies ensure consistency and reliability in operations, leading to better quality control and customer satisfaction. Companies should invest in training programs to educate employees on these strategies and ensure their successful implementation.

Again, based on the analysis conducted, there was no significant relationship between standardised work and product output, which is consistent with the findings of Akhter *et al*. (2016). In contrast, there was a significant positive relationship between standardised work and product quality, similar to the findings of Polat *et al*. (2018) and Aung and Tun (2019). However, no significant relationship was found between standardised work and operational performance, which is in line with the findings of Great and Offiong (2023). This goes to show from the above that manufacturing companies in Benin City, Edo State should prioritize ergonomic conditions in their production lines as this is crucial for improving both product output and operational performance. Ergonomic design considerations can minimize physical strain on workers, reduce the risk of injuries, and enhance overall productivity. Investing in ergonomic equipment and workspace layout optimization can create a safer and more conducive work environment, leading to increased employee satisfaction and morale. Companies should conduct regular ergonomic assessments and solicit feedback from workers to identify areas for improvement and implement appropriate interventions.

Finally, the analysis indicated a significant positive relationship between ergonomic conditions and product output, which supports the findings of Unuigbe *et al*. (2016).Similarly, a significant positive relationship was found between ergonomic conditions and product quality, which aligns with the findings of Otto and Battaia (2017) and Polat *et al*. (2018). Furthermore, a significant positive relationship was observed between ergonomic conditions and operational performance, consistent with the findings of Sridhar *et al*. (2017) and Manaye (2019). Manufacturing companies in Benin City, Edo State should adopt a culture of continuous improvement, encouraging employees to identify and address inefficiencies in production processes. Regular performance evaluations and feedback mechanisms can facilitate data-driven decision-making and drive operational excellence. By embracing a mindset of continuous improvement, companies can adapt to changing market dynamics, enhance competitiveness, and achieve sustainable growth.

CHAPTER FIVE

SUMMARY OF FINDINGS, CONCLUSION AND RECOMMENDATIONS

5.1 Introduction

In this chapter, we embark on a comprehensive synthesis of the research journey, culminating in the distillation of significant insights and implications. The sections that follow encapsulate the culmination of rigorous empirical analysis, leading to a nuanced understanding of the research questions. The amalgamation of findings, conclusions drawn from these findings, and strategic recommendations forms the crux of this chapter. The summary of findings, the conclusion, practicable recommendations, the essence of the study's contribution to knowledge and its potential impact on real-world applications were also presented.

5.2 Summary of Findings

1. The study revealed there is a positive and significant relationship between one-piece flow and operational performance of Manufacturing Companies in Benin City.
2. It also found that there is a significant non-positive relationship between standardised work and operational performance of Manufacturing Companies in Benin City.
3. Finally, the study found that there is positive and significant relationship between ergonomic conditions of a production line and operational performance of Manufacturing Companies in Benin City.

5.3 Contributions to Knowledge

This study has made the following contributions to the body of knowledge:

1. This study contributes to knowledge by identifying that a substantial and positive correlation exists between the implementation of one-piece flow methodologies and the operational performance of Manufacturing Companies in Benin City as it contributes to efficiency enhancement, minimizing delays, optimizing operational efficiency, and improving operational performance through resource utilization, reduced lead times, and timely delivery. It aligns with lean manufacturing principles and focuses on waste reduction, enhancing cost-effectiveness, streamlining operations, and boosting profitability. The methodology's adaptability and flexibility, seen in smaller batch sizes, enables effective responses to changing market demands, crucial for competitiveness in dynamic industries and positively impacting overall operational performance.
2. The study also contributes to knowledge by identifying a significant non-positive relationship between standardised work strategies and the operational performance of Manufacturing Companies in Benin City as standardised work, while beneficial in certain contexts, might face challenges or limitations in this specific industrial setting, Rigid adherence to standardised procedures may hinder creativity and innovation, particularly in industries where adaptability is crucial. The dynamic nature of tasks in such settings may not align with strict standardised strategies, influencing operational performance negatively.

Additionally, depending on the nature of the work and the workforce, adhering strictly to standardised procedures might impact employee morale and engagement. Instances where employees feel restricted or disengaged may not yield the anticipated positive impact on operational performance.

3. The study also uncovered a positive and significant relationship between the ergonomic conditions of a production line and the operational performance of Manufacturing Companies in Benin City as ergonomic conditions contribute to the well-being and health of employees. A healthy workforce is likely to be more productive, leading to improved operational performance through reduced absenteeism, enhanced morale, and increased job satisfaction. Ergonomic work environments are designed to optimize the physical and cognitive capabilities of workers leading to increased efficiency, fewer errors, and smoother operations, positively influencing overall operational performance. Providing ergonomic conditions enhances an organization's attractiveness to potential employees and contributes to employee retention as a stable and satisfied workforce is a valuable asset for operational performance, as it ensures continuity and expertise within the organization.
4. Lastly, the study contributes to the literature by testing out the production line strategies and operational performance using the Ordinary Least Squares (OLS) method further affirming that production line strategies is crucial for improved operational performance.

5.4 Conclusion

In conclusion, this study delved into the intricate relationship between production line strategies and the operational performance of Manufacturing Companies in Benin City. The empirical analysis has uncovered nuanced findings, highlighting both positive and non-positive correlations with distinct aspects of production methodologies. The positive relationship between the implementation of one-piece flow methodologies and operational performance underscores the efficiency enhancement, waste reduction, and adaptability fostered by this approach. Aligning with lean manufacturing principles, it contributes to streamlined operations, enhanced cost-effectiveness, and increased profitability. The adaptability inherent in smaller batch sizes ensures responsiveness to dynamic market demands, positively impacting overall operational performance. Conversely, the significant non-positive relationship found in standardised work strategies highlights potential challenges in its application within this specific industrial setting. Rigid adherence may impede creativity and innovation, particularly in dynamic industries where adaptability is paramount. The study emphasizes the need for a flexible approach to standardised work to avoid negative impacts on operational performance, considering task nature, workforce dynamics, and creativity requirements. Furthermore, the positive relationship uncovered between ergonomic conditions and operational performance accentuates the importance of employee well-being. A healthy workforce is demonstrated to be more productive, contributing to reduced absenteeism, enhanced morale, and increased job satisfaction. Ergonomic work environments optimize the capabilities of workers, resulting in increased efficiency and smoother operations, positively influencing overall operational performance. Lastly, the study contributes to the literature by employing the Ordinary Least Squares (OLS) method, affirming the crucial role of production line strategies in improving operational performance. This research thus provides valuable insights that extend beyond theoretical frameworks, offering practical implications for manufacturing companies in Benin City seeking to enhance their operational performance through production line strategies.

5.5 Recommendations

Based on the findings of this study, the following recommendations were made:

1. Manufacturing Companies in Benin City may need to consider adopting and implementing one-piece flow methodologies thus promoting a continuous and smooth production process, minimizing delays, and optimizing overall operational efficiency. Also, training programs can be introduced to familiarize the workforce with the principles of one-piece flow, fostering a culture of continuous improvement.
2. they should carefully balance the implementation of standardised work to avoid potential by assessing the nature of tasks, workforce dynamics, and the level of creativity required, thus avoiding potential negative impacts on operational performance. In dynamic industries where adaptability and innovation are crucial, a flexible approach to standardised work may be more beneficial.

3. lastly, manufacturing companies should prioritise creating ergonomic work environments for their production lines by investing in equipment and facilities that optimize the physical and cognitive capabilities of employees. They should also conduct regular ergonomic assessments and solicit feedback from the workforce that can help tailor these conditions to specific needs. Employee well-being programs and awareness campaigns also can further support a healthy work environment.

5.6 Suggestions for Further Research

Based on the scope of this study, the employees of manufacturing companies in Benin City, Edo State, Nigeria were sampled. It is therefore recommended that future research be extended to include other manufacturing companies in other states in Nigeria at large. Future research should also attempt to examine the relationship between production line strategies and supply chain resilience. There is also the need to investigate the impact of integrating Industry 4.0 technologies, such as IoT devices, AI-driven analytics, and smart manufacturing systems, in achieving a production line. These future studies can also conduct in-depth studies on employee perceptions regarding one-piece flow, standardised work, and ergonomic conditions. Comparative analysis across industries, how operational culture factors such as leadership styles, communication patterns, and operational values influences the successful adoption and implementation of production line strategies and outcomes of these strategies can also be looked at.

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APPENDIX

QUESTIONNAIRE ON PRODUCTION LINE STRATEGIES AND OPERATIONAL PERFORMANCE

SECTION A: DEMOGRAPHIC DATA

Instructions: Please tick (√) the appropriate options and fill the spaces provided.

1. Gender: Male ( ), Female ( )
2. Education: College Level ( ), Bachelor's degree ( ), Master's degree ( ), Doctoral degree (), Others ( ).
3. Which of the following positions do you occupy in your organisation? Production manager ( ), Factory supervisor ( ), Assembly (line) supervisor ( ).
4. Years of experience in your organisation: 1-5 years ( ), 6-10 years ( ), 11-15 years ( ), 16-20 years ( ).

SECTION B

This section contains questions on both the dependent variable (Operational performance) and the independent variable (production line strategies).

Key: SD (Strongly Disagreed); D (Disagreed); U (Undecided); A (Agreed); SA (Strongly Agreed).

S/N		SD	D	U	A	SA
	INFLUENCE OF ONE-PIECE FLOW ON OPERATIONAL PERFORMANCE **One-piece flow:** *A production system where items produced or processed are moved one unit at a time from the first stage to the final stage without work-in-process inventory between the stations*					
5	Cuts down wastages in terms of cost and space					
6	Increases production processing times					
7	Increases quantity produced					
8	Boosts workers' morale					
9	Makes product defects easy to spot					

10	Reduces the quality of products					
11	Eliminates bottlenecks in the production process					
12	Allows for workers' innovativeness					
13	Causes the work to be monotonous					
	INFLUENCE OF STANDARDISED WORK ON OPERATIONAL PERFORMANCE **Standardised work:** *the systematic determination and documentation of the steps of a job task and the sequence in which they should be performed.*	**SD**	**D**	**U**	**A**	**SA**
14	Work standardization helps the organisation reduce product defects					
15	The use of standardised work improves workers' productivity					
16	The organisation finds it easy to meet customers' demands when works are standardised					
17	Adopting work standardization allows workers to easily identify areas that need improvement					
18	It reduces jobs processing times when organisations adopt work standardization					
19	Using work standardization lowers the quality of items produced.					
20	By giving employees the ability to identify possible improvement areas, standardised work helps them develop a sense of ownership and competency in their careers.					
21	It makes the jobs to be monotonous					
22	Standardised work elicits zero workers initiatives.					
	INFLUENCE OF WORK PLACE ERGONOMICS ON OPERATIONAL PERFORMANCE **Work place Ergonomics:** *the arrangement of the workplace, products and systems in a way that optimizes the wellbeing of the workers as well as the performance of the organisation.*	**SD**	**D**	**U**	**A**	**SA**
23	Successful implementation of workplace ergonomics on a production line makes the workers to be more focused on their jobs					
24	It brings about improved workers' productivity					
25	Work place ergonomics increases production efficiency					
26	Product quality is positively affected because workers are more focused on their jobs.					
27	Increases workers involvement in the production process					

28	It increases the number of workers turnover rate					
29	Brings about unhappy employees					
30	Fewer work injuries saves cost for the organisation					
31	Reduces workers absenteeism					
	OPERATIONAL PERFORMANCE	**SD**	**D**	**U**	**A**	**SA**
	Product Output:*the quantity of goods produced in a specific time period using available resources.*					
32	Production rate has increased this period.					
33	There is a reduction in customers' lead-time this period.					
34	Cost of production has increased significantly					
35	Quantity produced has decreased greatly this period.					
	Product Quality'': *the extent to which satisfaction is met by the inherent elements in the product.*					
36	Product defects have reduced significantly this period.					
37	There is zero customer complaint about our products this season.					
38	Our products are positively rated this period.					
39	Customer demands for our products have decreased significantly over time.					