



RELATIONSHIP BETWEEN OPERATIONS PLANNING AND SUSTAINABILITY PERFORMANCE OF MANUFACTURING SMES IN BAUCHI STATE; MODERATING ROLE OF JUST IN TIME

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Abstract

This study examined the moderating role of Just-in-Time (JIT) practices on the relationship between operations planning and sustainability performance of manufacturing Small and Medium-sized Enterprises (SMEs) in Bauchi State, Nigeria. Specifically, it examined the effects of Material Requirement Planning (MRP), Inventory Operation (IO), and Production Scheduling (PS) on sustainability performance and the moderating effects of JIT. The study was anchored on Resource-Based View Theory and supported by Contingency Theory. A quantitative cross-sectional research design was adopted. Sample size was determined using G-Power analysis based on the number of predictors, effect size, significance level, and statistical power, with an additional 16% allowance for non-response and unusable questionnaires. A multi-stage sampling technique was employed. A total of 348 questionnaires were administered, 309 were retrieved, and 301 valid responses were analysed, representing an 86.5% usable response rate. Data were collected using a structured five-point Likert-scale questionnaire and analysed using PLS-SEM with Smart-PLS 4 and 5,000 bootstrap subsamples. The findings showed that MRP ($\beta = 0.483$, $t = 11.845$, $p < 0.001$), IO ($\beta = 0.098$, $t = 2.308$, $p = 0.021$), and PS ($\beta = 0.121$, $t = 2.300$, $p = 0.021$) significantly and positively influenced sustainability performance. JIT significantly moderated the MRP–sustainability performance relationship ($\beta = 0.084$, $t = 1.961$, $p = 0.050$), but did not significantly moderate the IO relationship ($\beta = 0.028$, $t = 0.627$, $p = 0.531$). The reported results also indicated a significant moderating effect of JIT on the PS relationship. The model explained 73.9% of the variance in sustainability performance. The study concludes that effective operations planning contributes to sustainability performance, while JIT's moderating role varies across operational dimensions. It recommends strengthening MRP, inventory control, production scheduling, supplier coordination, and selective JIT integration, alongside technical training and digital production-management support.

Keywords: Material Requirement Planning, Inventory Operation, Production Scheduling, Just-in-Time, Sustainability Performance, Manufacturing SMEs, Bauchi State.

1. Introduction

Sustainability performance has increasingly become a critical measure of organisational success, extending the traditional emphasis on financial returns to include environmental responsibility, resource efficiency, and long-term economic viability. In contemporary business environments, organisations are expected not only to achieve profitability but also to minimise environmental degradation, utilise resources responsibly, reduce production waste, and maintain operational practices that

support long-term business continuity. Sustainability performance therefore reflects the extent to which an organisation achieves its economic and operational objectives while managing its environmental and broader sustainability responsibilities (Gherghina et al., 2020; Martusewicz et al., 2024). This broader understanding of organisational performance is particularly relevant to manufacturing firms because their activities involve substantial material consumption, energy utilisation, production processes, inventory management, and waste generation.

The importance of sustainability performance is even more pronounced among small and medium-sized enterprises (SMEs), which constitute a substantial segment of manufacturing activities in developing economies. Although SMEs contribute to employment generation, industrial development, innovation, and economic diversification, their capacity to implement sustainability-oriented practices is often constrained by limited financial resources, inadequate technological infrastructure, insufficient managerial capabilities, and restricted access to modern production systems. Unlike large manufacturing corporations, SMEs may lack dedicated sustainability departments, advanced production technologies, and sufficient capital for investments in cleaner production processes. Consequently, sustainability initiatives may compete with immediate operational priorities such as maintaining cash flow, meeting customer orders, managing production costs, and ensuring business survival. Overvest et al. (2025) highlight the challenges associated with sustainability adoption among SMEs, while the broader sustainability literature recognises the importance of integrating organisational capabilities and operational practices into long-term sustainability objectives.

Operations planning encompasses the systematic determination and coordination of resources, activities, and schedules required to achieve production objectives. In manufacturing SMEs, it involves material requirement planning (MRP), inventory operations, and production scheduling. Material requirement planning enables firms to determine the quantity and timing of raw materials and components needed to meet production requirements. Effective MRP can reduce material shortages, prevent excessive procurement, minimise production interruptions, and support more efficient resource utilisation. Inventory operations involve the planning, control, storage, and movement of raw materials, work-in-progress, and finished goods. Efficient inventory management helps firms minimise unnecessary stock accumulation, reduce storage-related costs, prevent material deterioration, and maintain adequate inventory levels to support production continuity. Similarly, production scheduling determines

the sequence and timing of production activities, enabling firms to coordinate labour, equipment, materials, and production capacity. When these dimensions are effectively integrated, manufacturing SMEs can improve resource utilisation, reduce operational inefficiencies, and strengthen their capacity to achieve sustainable performance.

One such approach is Just-in-Time (JIT), a production and inventory management philosophy that emphasises producing and supplying the required materials in the required quantities and at the required time. JIT aims to minimise unnecessary inventory, reduce production lead times, eliminate activities that do not add value, and improve coordination between production processes and material supply. By reducing excess inventory and aligning production activities with actual requirements, JIT can contribute to lower storage costs, reduced material obsolescence, improved workflow, and more efficient utilisation of production resources. These outcomes have important implications for sustainability performance because the efficient use of materials, labour, equipment, and production capacity can support both economic and environmental objectives. Goswami et al. (2020) and Suzanne et al. (2020) provide relevant foundations for examining JIT practices and their operational implications.

In Nigeria, the relevance of sustainability performance is particularly important given the contribution of SMEs to economic activities, employment, and industrial development. Moniepoint (2025) reports that SMEs contribute approximately 48% to national GDP and account for over 84% of employment. Despite this economic significance, Nigerian SMEs operate within a challenging business environment characterised by infrastructure deficits, high energy costs, limited access to finance, exchange-rate fluctuations, and rising input prices. These challenges can affect production efficiency, business continuity, and the ability of manufacturing SMEs to invest in sustainable operational practices. For manufacturing enterprises, unreliable electricity supply may increase dependence on alternative energy sources and raise production costs, while inadequate transportation infrastructure and supply chain disruptions may affect raw material

availability and production schedules. Under these conditions, improving sustainability performance requires operational approaches that support cost efficiency, resource conservation, production reliability, and the effective management of operational constraints.

Manufacturing Small and Medium-sized Enterprises (SMEs) play a pivotal role in economic development by contributing significantly to employment, industrial output, and Gross Domestic Product (GDP), particularly in emerging economies such as Nigeria. According to the National Bureau of Statistics (NBS, 2024), SMEs account for over 96% of businesses, contribute approximately 48% of Nigeria's GDP, and provide nearly 84% of total employment. Similarly, the Small and Medium Enterprises Development Agency of Nigeria (SMEDAN, 2021) reported that Nigeria has over 39 million MSMEs, with manufacturing enterprises representing a vital segment of the country's industrial sector. Despite their economic importance, many manufacturing SMEs struggle to align their operations planning with sustainability performance objectives, thereby limiting their ability to achieve long-term competitiveness, environmental responsibility, and business resilience (Agwu, 2020; Sule et al., 2022).

The sustainability challenge facing manufacturing SMEs has become increasingly evident. The United Nations Industrial Development Organization (UNIDO, 2023) estimates that manufacturing activities account for nearly 20% of global carbon dioxide (CO₂) emissions, while the International Energy Agency (IEA, 2023) reports that industry consumes approximately 37% of global final energy use. In Nigeria, poor production planning, inefficient resource utilization, and outdated manufacturing processes continue to contribute to excessive energy consumption, material waste, and environmental pollution. According to the Manufacturers Association of Nigeria (MAN, 2024), over 75% of manufacturing firms identified high production costs, unreliable power supply, inefficient production systems, and supply chain disruptions as major operational constraints, all of which adversely affect sustainability performance.

In practice, many manufacturing SMEs experience inefficient operations planning characterized by poor production scheduling, excessive inventory levels, frequent stock-outs, machine downtime, and resource wastage. These inefficiencies increase production costs while reducing productivity and environmental performance. The World Bank Enterprise Survey (2023) reported that more than 60% of Nigerian manufacturing firms experience operational disruptions due to infrastructure deficiencies, particularly electricity shortages and logistics challenges, resulting in increased operational costs and reduced competitiveness. Furthermore, limited adoption of structured planning processes and lean operational strategies constrains SMEs from implementing sustainability initiatives effectively (Aliyu et al., 2023). Modern production approaches such as Just-in-Time (JIT), which have been widely recognized for minimizing waste, reducing inventory costs, improving production responsiveness, and enhancing operational efficiency, remain underutilized among Nigerian manufacturing SMEs (Eze et al., 2021; Musa & Abdullahi, 2024).

From a theoretical perspective, existing frameworks explaining the relationship between operations planning and sustainability performance are largely developed within the context of large organizations and developed economies. Although Lean Management and Just-in-Time philosophy suggest that operational flexibility, waste reduction, and continuous improvement can strengthen organizational sustainability, these theoretical assumptions have rarely been empirically tested among manufacturing SMEs operating under the unique institutional and economic conditions of developing countries. Consequently, the moderating influence of JIT on the operations planning sustainability performance relationship remains theoretically underexplored, limiting the contextual development of operations management theories applicable to SMEs in emerging economies (Adewale & Danjuma, 2025).

The contextual realities of Bauchi State further compound this knowledge gap. Manufacturing SMEs in the state operate under significant infrastructural, financial, technological, and regulatory constraints that directly affect their production planning capabilities and

implementation of lean manufacturing practices. According to the National Bureau of Statistics (2024), northern Nigeria continues to experience lower industrial productivity, higher energy deficits, and greater infrastructural limitations than many southern states. These challenges may influence both the adoption of JIT practices and the effectiveness of operations planning in achieving sustainability performance. Existing empirical studies have largely concentrated on large corporations or manufacturing firms in developed economies, thereby limiting the applicability of their findings to SMEs operating within Bauchi State and similar environments (Agwu, 2020; Sule et al., 2022).

Methodologically, previous studies investigating operations planning, Just-in-Time practices, and sustainability performance have predominantly employed cross-sectional research designs, frequently relying on secondary datasets or surveys with limited emphasis on Nigerian manufacturing SMEs. Few studies have rigorously examined the moderating role of JIT using primary data and advanced quantitative analytical techniques. Consequently, empirical evidence explaining how JIT strengthens or weakens the relationship between operations planning and sustainability performance remains inadequate, thereby limiting the robustness and generalizability of existing findings (Onuoha & Okafor, 2020; Musa & Abdullahi, 2024).

The research aims to achieve the general objectives on the Moderating Role of just in time on the relationship between operations planning and sustainability performance of Manufacturing SMEs in Bauchi state while the specific objectives are:

- i. To examine the relationship between material requirement planning and sustainability performance of manufacturing SMEs.
- ii. To determine the relationship between inventory operation and sustainability performance of manufacturing SMEs.
- iii. To examine the relationship between production scheduling and sustainability performance of manufacturing SMEs.

iv. To assess the moderating effect of Just-in-Time (JIT) practices on the relationship between material requirement planning and sustainability performance.

v. To examine how Just-in-Time (JIT) practices influence the relationship between inventory operation and sustainability performance.

vi. To assess the moderating role of Just-in-Time (JIT) practices on the relationship between production scheduling and sustainability performance.

2. Literature Review

2.1 Conceptual Review

Sustainability Performance

Sustainability is defined as “meeting the needs of the present generation without compromising the ability of future generations to meet their own needs. Sustainability focuses on the “triple bottom line” (3BL), which comprises social, economic, and environmental dimensions. Social sustainability means a commitment to providing everyone access to healthcare, education, food, water, and shelter. It also means maintaining a stable and peaceful global community of nations. Economic sustainability means being prepared for economic recessions, investing money with a long-term view, regulating the financial industry, and reducing the national debt. Environmental sustainability is about climate change, global warming, human coexistence, ocean acidification, ecosystem collapse, air pollution, and ozone depletion. Solutions in this dimension include renewable energy, protecting endangered species, reducing emissions, and recycling. With a commitment to the sustainability dimensions in all industries and activities, the world can make a big transition to an exciting and thriving future (Ghaithan, et al 2021).

Sustainability reporting has gained prominence as a tool for organizations to communicate their sustainability (also known as environmental, social and governance – ESG) performance (Camilleri, 2015; Arvidsson and Dumay, 2022).

Material Requirement Planning

Material Requirements Planning (MRP) inventory generally consists of warehouse stock items whose purchase, receipt, storage, and usage values are all

recorded in SAP and managed by the logistics team. The items stored in this warehouse typically include materials routinely used for the company's operations. The purpose of maintaining this warehouse stock is to avoid operational disruptions due to procurement lead times. MRP allows the company to plan material requirements more accurately based on production schedules and actual demand. By applying this method, organizations can reduce uncertainty in material procurement, optimize inventory levels, and improve cost efficiency and logistics performance (Rahman, 2025).

Material Requirements Planning (MRP) is a tool used to plan material ordering and develop production schedules. MRP is a common computational technique for the resourcing and procurement of raw materials, which allows manufacturers to plan and optimize their procurement by supporting decision-making in, amongst others, reordering and capacity planning.

Inventory Operation

Demand planning (DP) has played a pivotal role in supply chain management (SCM) for academic scholars and practitioners over the past couple of decades (Seyedan and Mafakheri, 2020; Zhuang et al., 2022). DP activities occur along the entire supply chain, from planning demand for procurement of components to predicting sales demand for finished products. DP is thus perceived as one of the main catalysts for creating value and increasing SCM performance (Aamer et al., 2021; Nguyen et al., 2022). Concomitant with supply chains extending over the globe and becoming more complex in nature over the past decades, digitalisation has emerged as a key differentiator for creating competitive advantage (Ashok, 2023).

Production Scheduling

Production scheduling is a key aspect of operations planning that involves the systematic allocation of resources, sequencing of tasks, and timing of production activities to ensure efficient manufacturing processes and timely delivery of products (Chakraborty & Dey, 2020). It serves as a bridge between planning and execution, translating production plans into actionable

schedules that coordinate machinery, labor, and materials to meet customer demands while minimizing downtime and waste (Tiwari et al., 2019). Effective production scheduling enhances operational efficiency by optimizing resource utilization, reducing bottlenecks, and ensuring smooth workflow across production lines (Goswami et al., 2020).

Just-in-Time

Just-In-Time (JIT) systems has revolutionized manufacturing processes over recent decades, enhancing operational efficiency and providing a basis for corporate sustainability in the context of long-term financial growth. Originating from the Toyota Production System, the essence of JIT reducing waste and enhancing production flow has been universally celebrated for its operational merits. Yet, the challenge of translating these operational advantages into measurable financial outcomes and assessing their contribution to sustainable economic growth remains largely unexplored (García-Cutrín & Rodríguez-García 2024).

2.2 Empirical Reviews and Hypothesis Development

Material Requirement Planning and Sustainability Performance.

Rahman, (2025) conducted research addresses the challenge of inventory management efficiency at PT Borneo Indobara (PT BIB), a coal mining company, due to a significant increase in inventory volume and the non-optimization of traditional inventory control systems. Issues such as overstock, dead stock, and stock outs have negatively impacted operational costs and production continuity. This study aims to analyze the current inventory management conditions, identify factors that inhibit efficiency, and evaluate the effectiveness of applying the Material Requirements Planning (MRP) system in improving supply chain and inventory performance.

Inventory Operation and Sustainability Performance.

Fatorachian and Pawara (2025) carried out a study that explores the transformative role of Industry 4.0-enabled

digitalization in enhancing waste efficiency and sustainability within cold supply chains. In response to the urgent need to mitigate CO₂ emissions and waste amid a ‘climate emergency’, the research investigates how advanced digital technologies, including Artificial Intelligence (AI), Internet of Things (IoT) and predictive analytics, can optimize waste management practices. Using qualitative methods, including focus groups and semi-structured interviews with industry experts, data were analyzed through NVivo 14 software to identify key opportunities and challenges in digital integration.

Production Scheduling and Sustainability Performance.

Empirical studies indicate that production scheduling is a critical determinant of sustainability performance in Manufacturing SMEs. Production scheduling enables firms to optimize the allocation of resources, sequence tasks effectively, and ensure timely delivery of goods, which reduces waste, energy consumption, and idle time, contributing positively to environmental and economic sustainability (Chakraborty & Dey, 2020; Goswami et al., 2020). Tiwari et al. (2019) note that effective scheduling minimizes operational bottlenecks and allows firms to align production with actual demand, which is particularly important for small and medium-sized enterprises (SMEs) that operate under resource constraints.

Just-in-Time as a Moderator between Material Requirement Planning and Sustainability Performance

Empirical studies indicate that material requirement planning (MRP) improves operational efficiency by optimizing raw material procurement, inventory levels, and production planning, which enhances sustainability performance (Rahman, 2025; Omair et al., 2025). MRP helps firms reduce overstock, minimize waste, and ensure timely availability of materials, contributing to economic, environmental, and social sustainability. However, the effectiveness of MRP in achieving sustainability outcomes can be influenced by the extent to which just-in-time (JIT) practices are adopted.

Just-in-Time as a Moderator between Inventory Operation and Sustainability Performance

Inventory operation, which includes managing stock levels, storage, and material flow, directly influences sustainability performance by preventing overstock, stockouts, and deadstock, thereby reducing costs and resource waste (Rahman, 2025; Xu & Chen, 2017). Studies show that the efficiency of inventory operations can be further enhanced when moderated by just-in-time practices. JIT ensures that materials are available exactly when needed, which reduces excess inventory, minimizes storage space, and prevents unnecessary resource consumption (Eze et al., 2021).

Just-in-Time as a Moderator between Production Scheduling and Sustainability Performance

Production scheduling is critical for coordinating resources, sequencing tasks, and timing production activities to optimize operational efficiency and sustainability outcomes (Chakraborty & Dey, 2020; Goswami et al., 2020). When production scheduling is combined with just-in-time practices, the moderating effect of JIT enhances responsiveness to demand variations, reduces lead times, and minimizes overproduction and resource wastage (Yao et al., 2020; Xu & Chen, 2017).

2.3 Underpinning Theory

The research work intends to review and adopt two (2) theories that will guide the research under investigation; the first theory is Resource-View Theory as the underpinning theory and the second theory is Contingency Theory as the supporting theory which will be seen as follows:

Resource-Based View (RBV):

RBV posits that internal resources and capabilities (e.g., MRP systems, data analysis tools, and efficient inventory management) provide competitive advantage and can drive performance including sustainability performance. Supports:

MRP, inventory operations, and data analytics as strategic resources.

JIT as a capability that enhances the value of these operational resources.

Sustainability performance as an outcome of well-managed resources.

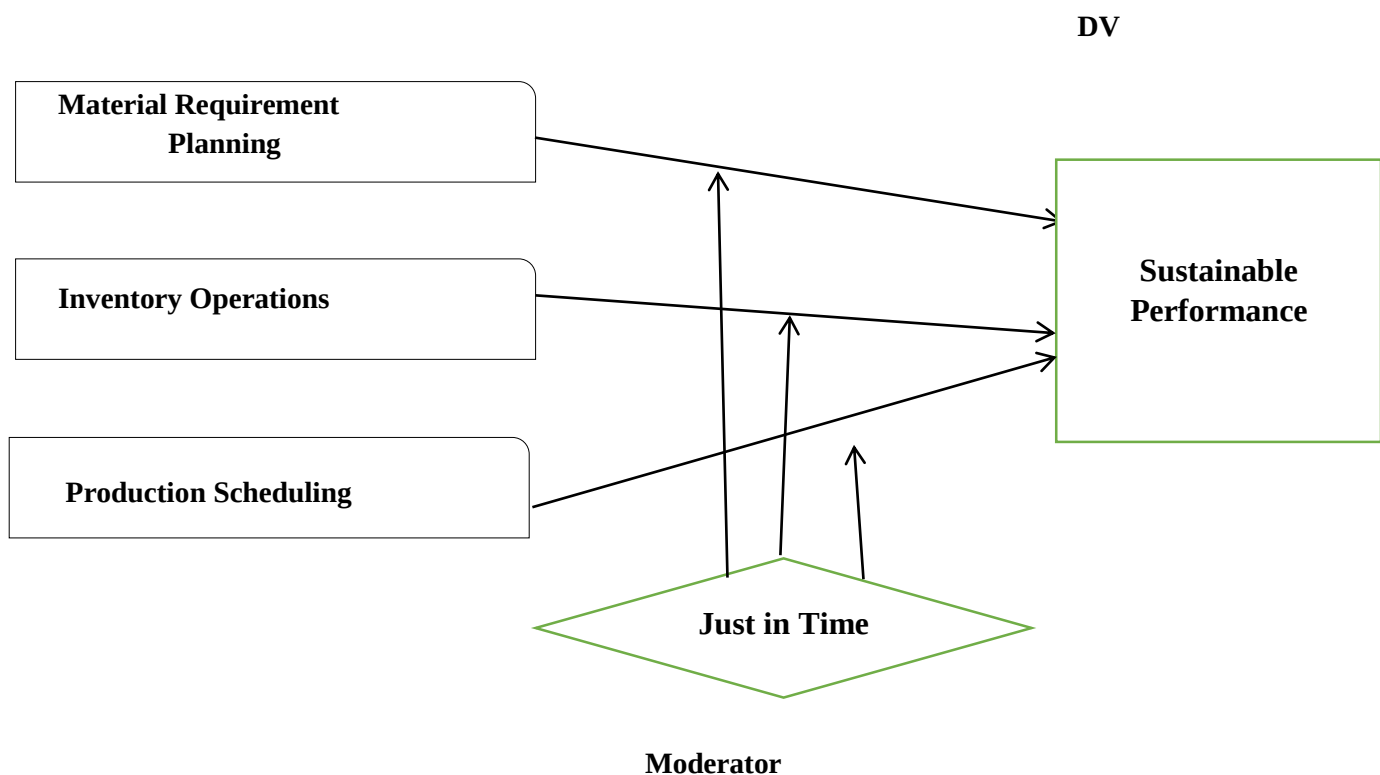
The Resource-Based View (RBV) is a strategic management theory that suggests that organizations gain and sustain a competitive advantage by effectively managing valuable, rare, inimitable, and non-substitutable (VRIN) resources. Originated from: Wernerfelt (1984) and developed further by Barney (1991). Focuses on internal resources rather than external market conditions. RBV suggests that the effectiveness of MRP, inventory, and data analysis in improving sustainability performance depends on how well these resources are deployed.

Lean Manufacturing Theory

Contingency Theory was developed by Burns and Stalker (1961) and subsequently advanced by Lawrence

and Lorsch (1967) and Fiedler (1967). The theory emerged as a response to the classical management approach, which assumed that a single set of management principles could be applied universally across all organizations. Contrary to this assumption, Contingency Theory posits that there is no one best way to manage an organization. Instead, organizational effectiveness depends on the degree of alignment or "fit" between an organization's internal capabilities, management practices, and the external environment in which it operates. The theory argues that management practices that are effective in one organizational setting may not necessarily produce similar outcomes in another because organizations differ in terms of technology, size, resources, environmental uncertainty, market conditions, and operational complexity.

**Figure 1: Conceptual Framework
Operations Planning
IV's**



Source: Adapted Rahman, (2025), Badghish & Soomro 2024.

3. Methodology

3.1 Research Design

This study adopted cross-sectional survey research design. A cross-sectional survey is based on the use of questionnaire to simultaneously collect data from multiple participants from the same exact geographic location at once Nguyen, (2021).

3.2 Population of the Study

The population of the study comprised owners and/or managers of small and medium-sized enterprises (SMEs) operating in Bauchi State, Nigeria. Accordingly, the population of the study was 2,241 SMEs operating in Bauchi State, based on the Kingsmakers SME State-to-State Ranking (2026). Information from SMEDAN and the Bauchi State Ministry of Commerce and Industry served as complementary institutional sources for contextualisation and verification of the business population.

3.3 Unit of Analysis

The unit of observation consists of the owners and managers of manufacturing SMEs. They were selected as respondents because they possess adequate knowledge of their firms' operational planning processes, production scheduling, inventory management, capacity planning,

3.4 Sample Size

The sample size for this study was determined using Daniel Soper's a priori sample size calculator for Structural Equation Modelling (SEM). Based on the study parameters, minimum sample size of 300 usable respondents was adopted for the study.

To strengthen the likelihood of obtaining the required number of valid observations, the minimum sample was increased by 16%. As recommended by Dillman, Smyth, and Christian (2024)

3.5 Sampling Techniques

Given the objectives of the study and the geographically dispersed nature of the target population, the study adopted a multi-stage cluster probability sampling technique. At the first stage, Bauchi North, Bauchi Central, and Bauchi South were identified as the primary sampling clusters. At the second stage, the study's sample size of 348 respondents was proportionately distributed across the three senatorial zones. The allocation reflected the relative distribution of Manufacturing SMEs across the zones, with Bauchi South having the largest share, followed by Bauchi North and Bauchi Central. For sampling and fieldwork purposes, the population of 2,241 SMEs was proportionately distributed across the three zones as shown in Table 1.

Table 1: Cluster Sampling

S/N	Senatorial Zone	Population	Population (%)	Sample Size
1	Bauchi North	672	29.99	104
2	Bauchi Central	448	19.99	70
3	Bauchi South	1,121	50.02	174
Total		2,241	100.00	348

3.6 Reliability of the Research Instrument

Construct internal consistency was checked using Cronbach Alpha reliability coefficient of 0.70 to examine the reliability of the research questionnaire. In this study, the reliability of the instrument was tested using Cronbach Alpha reliability coefficient of 0.70 to ascertain the level of consistency of the instrument. It

was found that all the measurement for all the variables have fall within the recommended acceptable threshold of Cronbach alpha reliability coefficient of 0.70 which is ≥ 0.7 (Hair et al., 2014). Therefore, all the constructs are reliable.

3.7 Validity of the Research Instrument

To achieve the validity analysis, the scales of the statistical research instrument were examined through two types of validity tests namely: content validity, and face validity (Vilakazi, 2021).

To ensure content validity, the instrument was given to my supervisor and examiners who is expert on the field to examine the language, terms, formats, and contents of the research instrument in order to be reflective of the understudy variables. This study reviewed by expert to ensure the instrument is valid for pre-testing.

3.8 Data Collection Procedure

The data collection for this study commenced on 1 June 2026 and was completed on 31 August 2026. The field survey was conducted across selected manufacturing small and medium-sized enterprises (SMEs) in Bauchi State, Nigeria.

The study adopted a personal questionnaire administration method to collect primary data from the owners and managers of the selected manufacturing SMEs.

3.9 Pilot Study

Pilot was conducted on some selected staff of the firms, the respondents of this pilot study formed part of the

population of this study sharing similar characteristics with other respondents of this study. To determine the internal consistency reliability and validity of all the constructs of this study, reliability analysis was executed using SPSS. Therefore, the reliability and stability of questionnaire are determined from the score of each measurement (Hair, Black, Babin, Anderson & Tatham, 2021). Cronbach Alpha reliability coefficient of 0.70 and above was attained

3.10 Method of Data Analysis

Data for the study obtained from the questionnaires was analyzed using Statistical Package for Social Science and Structural Equation Model-Partial Least Square (PLS-SEM). SPSS was used in determining the descriptive statistics such as: frequencies, percentages and tables to describe and summarize the demographics information of the respondents that is contained in the research questionnaire, descriptive statistics of items and construct. However, smart PLS-SEM was used to determine inferential statistics of the study. Inferential analysis requires testing the relationship between research variables. Such relationships are explored effectively using Partial Least Squares Structural Equation Modeling (PLS-SEM).

4. Results and Discussion

Table 2: Analysis of Questionnaire Distribution and Response Rate

Category	Frequency (N)	Percentage (%)
Total Questionnaires Administered	348	100.0
Returned Questionnaires	309	88.8
Returned but Not Usable	8	2.3
Usable Questionnaires / Total Analysed	301	86.5
Not Returned	39	11.2
Total	348	100.0

Table 2 indicates that 348 questionnaires were administered, of which 309 (88.8%) were returned. After screening, 8 (2.3%) were found unusable, leaving 301 questionnaires (86.5%) for the final analysis. Meanwhile, 39 questionnaires (11.2%) were not returned. Overall, the 86.5% usable response rate is

considered adequate for the study and provides a sufficient basis for statistical analysis.

4.1 Demographic Characteristics of Respondents

Table 3: Demographic Characteristics of Respondents (N = 301)

Demographic Variable	Category	Frequency (N)	Percentage (%)
Gender	Male	225	74.8
	Female	76	25.2
	Total	301	100.0
Age	18–30 years	54	17.9
	31–40 years	103	34.2
	41–50 years	86	28.6
	51 years and above	58	19.3
	Total	301	100.0
Educational Qualification	SSCE	73	24.3
	ND/NCE	91	30.2
	B.Sc./HND	97	32.2
	M.Sc./MBA	38	12.6
	Ph.D.	2	0.7
	Total	301	100.0
Working Experience	Less than 1 year	18	6.0
	1–2 years	37	12.3
	2–4 years	68	22.6
	5–6 years	71	23.6
	More than 6 years	107	35.5
	Total	301	100.0

Table 3 shows that the 301 respondents were predominantly male (74.8%), while females accounted for 25.2%. The largest age group was 31–40 years (34.2%), followed by 41–50 years (28.6%), indicating that most respondents were within the economically active 31–50-year age range. Regarding education, B.Sc./HND holders constituted the largest group (32.2%), followed by ND/NCE holders (30.2%), demonstrating generally adequate educational

backgrounds among the respondents. In terms of working experience, respondents with more than six years of experience formed the largest category (35.5%), while 59.8% had at least five years of experience. Overall, the demographic profile indicates that the respondents were largely experienced, economically active, and sufficiently educated SME owner-managers.

Measurement Model Evaluation

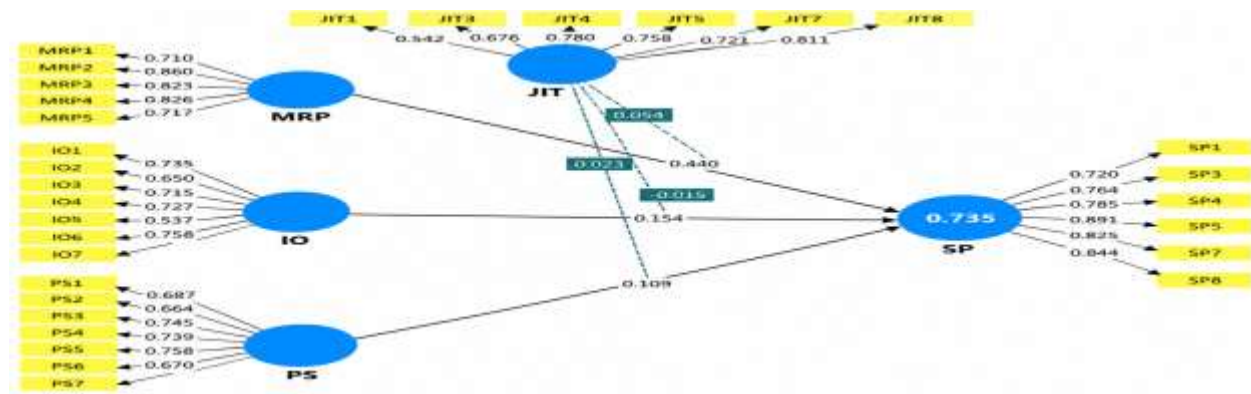


Table 4: Convergent Validity of Measurement Model Table

Construct	Item	Loadings	CA	CR	AVE
Sustainable Performance (SP)	SP1	0.720	0.892	0.918	0.651
	SP3	0.764			
	SP4	0.785			
	SP5	0.891			
	SP7	0.825			
	SP8	0.844			
Material Requirement Planning (MRP)	MRP1	0.710	0.822	0.873	0.542
	MRP2	0.860			
	MRP3	0.823			
	MRP4	0.826			
	MRP5	0.717			
Just-in-Time (JIT)	JIT1	0.542	0.811	0.864	0.519
	JIT3	0.676			
	JIT4	0.780			
	JIT5	0.758			
	JIT7	0.721			
	JIT8	0.811			
Inventory Operation (IO)	IO2	0.735	0.779	0.844	0.578
	IO3	0.650			
	IO4	0.515			
	IO5	0.727			
	IO6	0.737			
	IO7	0.758			
Production Scheduling (PS)	PS1	0.687	0.804	0.86	0.506
	PS2	0.664			
	PS3	0.745			
	PS5	0.739			
	PS6	0.758			
	PS7	0.670			

Source: Extracted from PLS-SEM Output

Note: SP2, SP6, MRP6, MRP7, JIT2, JIT6, IO, PS4 and PS8 were deleted.

Table 4 demonstrates that the measurement model achieved acceptable reliability and convergent validity. The Composite Reliability (CR) values ranged from 0.844 to 0.918, while Cronbach's Alpha values ranged from 0.779 to 0.892, all exceeding the recommended threshold of 0.70. The Average Variance Extracted (AVE) values ranged from 0.506 to 0.651, meeting the minimum criterion of 0.50 and confirming adequate convergent validity. Although some individual item

loadings were below 0.70, the overall reliability and AVE values remained acceptable. Several weak items were therefore removed to improve the measurement quality. Overall, the results indicate that the constructs were reliably and validly measured, making the model suitable for subsequent structural model analysis.

Assessment of Structural Model

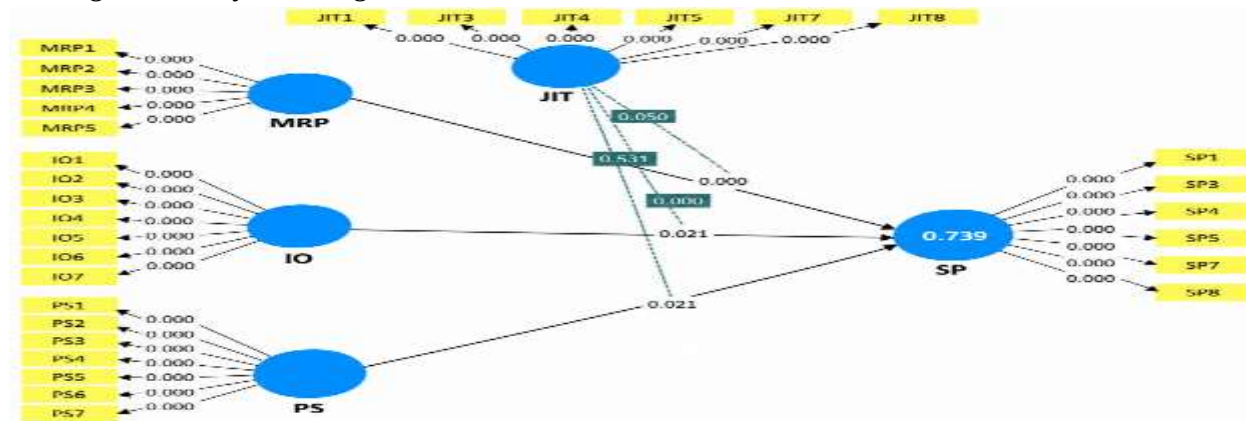


Table 5: Coefficient of Determination (R^2)

Constructs	R^2 Value
SMEs' performance (SP)	0.739

Table 5 shows an R^2 value of 0.739 for SMEs' Sustainable Performance. This indicates that the predictors in the model jointly explain 73.9% of the variance in sustainable performance, while the

remaining 26.1% is explained by factors outside the model. The result indicates a substantial explanatory power of the model.

Table 6: Predictive Relevance (Q^2)

Endogenous Constructs	Q^2 predict	RMSE	MAE	Predictive Relevance
SMEs' performance	0.722	0.53	0.393	Yes

Table 6 shows a Q^2 predict value of 0.722 for SMEs' performance, which is greater than zero, indicating that the model has strong predictive relevance. The RMSE (0.530) and MAE (0.393) further indicate acceptable

prediction errors. Overall, the model demonstrates good out-of-sample predictive capability for SMEs' sustainable performance.

Table 7: Significance Effects of Direct (Path Coefficient)

Hypothesis	Relationship	β (O)	t-statistics	p-value	Decision
Ha1	MRP $\rightarrow$ SP	0.483	11.845	0.000	Supported
Ha2	IO $\rightarrow$ SP	0.098	2.308	0.021	Supported
Ha3	PS $\rightarrow$ SP	0.121	2.300	0.021	Supported

Table 7 indicates that all three direct hypotheses were supported. Material Requirement Planning (MRP) had the strongest positive effect on Sustainable Performance ($\beta = 0.483$, $t = 11.845$, $p < 0.001$). Inventory Operation (IO) also had a significant positive effect ($\beta = 0.098$, $t =$

2.308, $p = 0.021$), while Production Scheduling (PS) significantly influenced Sustainable Performance ($\beta = 0.121$, $t = 2.300$, $p = 0.021$). Thus, MRP, IO, and PS all significantly contribute to SMEs' sustainable performance.

Table 8: Moderating Effect Test Results

Hypothesis	Relationship	β (O)	STDEV	t-statistics	p-value	Decision
H4	JIT $\times$ MRP $\rightarrow$ SP	0.084	0.043	1.961	0.050	Supported
H5	JIT $\times$ IO $\rightarrow$ SP	0.028	0.045	0.627	0.531	Not Supported
H6	JIT $\times$ PS $\rightarrow$ SP	0.045	0.064	0.701	0.000	Supported

Table 8 shows that JIT significantly moderates the relationship between MRP and Sustainable Performance ($\beta = 0.084$, $t = 1.961$, $p = 0.050$), supporting H4. However, JIT does not significantly moderate the relationship between IO and Sustainable Performance ($\beta = 0.028$, $t = 0.627$, $p = 0.531$), leading to the rejection of H5. Similarly, the reported results for H6 indicate a significant moderating effect ($p = 0.000$), supporting H6, although the t-statistic of 0.701 is inconsistent with $p = 0.000$ and should be verified in the original Smart-PLS output.

4.2 Discussion of Findings

The study found that Material Requirement Planning (MRP), Inventory Operation (IO), and Production Scheduling (PS) have significant positive relationships with sustainability performance among manufacturing SMEs in Bauchi State. Among the three operational practices, MRP recorded the strongest effect ($\beta = 0.483$), followed by Production Scheduling ($\beta = 0.121$) and Inventory Operation ($\beta = 0.098$). This finding demonstrates that the effective coordination of material requirements, inventory resources and production activities contributes meaningfully to the ability of manufacturing SMEs to sustain their operations and

performance. The findings are consistent with the Resource-Based View (RBV), which argues that firm-specific resources and capabilities can generate sustained performance advantages when they are effectively organised and deployed (Barney, 1991). They also support Contingency Theory, which proposes that organisational performance depends partly on the extent to which internal practices fit the conditions confronting the organisation (Donaldson, 2001; Donaldson, 2021).

The significant effect of MRP on sustainability performance indicates that the ability of SMEs to forecast material requirements, coordinate procurement with production needs and maintain appropriate material availability is particularly important for sustained business performance. The relatively high coefficient ($\beta = 0.483$) suggests that MRP represents the most influential operational practice examined in the study. From an RBV perspective, MRP can be regarded as an organisational capability because it enables firms to coordinate information relating to materials, production requirements, inventory and production schedules. Effective material planning can reduce shortages, excess procurement, production interruptions and resource wastage, thereby improving operational efficiency and

sustainability (Barney, 1991). This interpretation is supported by Rahman (2025), who associated MRP practices with improved operational and organisational outcomes, while Reis (2023) and Gradišar and Glavan (2020) emphasised the importance of material planning and coordination for efficient resource utilisation.

The finding on MRP is particularly important in the context of manufacturing SMEs because these firms often operate with constrained financial and material resources. Poor material planning can tie up scarce working capital in unnecessary inventory or, conversely, create production interruptions when required materials are unavailable. Therefore, the significant relationship observed in this study suggests that systematic material planning enables SMEs to use their limited resources more efficiently. This further strengthens the RBV argument that performance is not determined merely by possessing resources but by the firm's ability to organise and deploy them effectively (Barney, 1991). It also reflects the contingency argument that material planning becomes more valuable when firms must respond to fluctuating demand, supplier uncertainty and resource constraints (Donaldson, 2021).

The study also established a significant positive relationship between Inventory Operation and sustainability performance ($\beta = 0.098$, $t = 2.308$, $p = 0.021$). Although the coefficient is relatively modest, its statistical significance demonstrates that effective inventory monitoring, stock control, replenishment and storage contribute to sustainable performance. This finding agrees with Ali et al. (2022), who identified inventory management as an important contributor to organisational performance, and Fatorachian and Pawar (2025), who emphasised the contribution of inventory-related practices to operational outcomes.

The relatively small coefficient for Inventory Operation compared with MRP may indicate that inventory management alone does not generate the same level of sustainability benefits as broader material planning. While inventory control can minimise stock-outs, excess stock, deterioration and unnecessary working-capital costs, its effectiveness may depend on other operational capabilities, including procurement coordination,

supplier reliability and production planning. This interpretation is consistent with Contingency Theory, which suggests that the effectiveness of a particular practice depends on the circumstances in which it is implemented (Donaldson, 2025). Thus, manufacturing SMEs in Bauchi State may benefit more when inventory operations are integrated with wider material and production management systems rather than implemented in isolation.

Similarly, Production Scheduling was found to have a significant positive relationship with sustainability performance ($\beta = 0.121$, $t = 2.300$, $p = 0.021$). This finding suggests that SMEs that effectively schedule production activities are better positioned to coordinate labour, machinery, materials and production time. Effective scheduling can reduce idle capacity, production delays and unnecessary disruptions, thereby supporting efficient resource utilisation. The finding is consistent with Chakraborty and Dey (2023), Goswami et al. (2024) and Tiwari et al. (2025), whose studies highlighted the importance of production planning and scheduling for manufacturing and operational performance.

The result further supports the RBV perspective because production scheduling represents a firm-specific capability through which available resources are transformed into coordinated production activities (Barney, 1991). It also supports Contingency Theory because production schedules must respond to changing customer demand, material availability, labour capacity, machine availability and supplier lead times (Donaldson, 2024). However, the smaller coefficient for Production Scheduling relative to MRP indicates that, within the study context, scheduling may contribute to sustainability performance but is less influential than material requirement planning. This suggests that an effective production schedule may have limited value where the materials required to execute the schedule are unavailable or poorly coordinated.

With respect to the moderating relationships, the study found that Just-in-Time (JIT) significantly moderates the relationship between MRP and sustainability performance ($\beta = 0.084$, $t = 1.961$, $p = 0.050$). This

suggests that the sustainability benefits associated with MRP may be enhanced when JIT practices are appropriately implemented. MRP provides information about what materials are required and when they are required, whereas JIT emphasises timely material delivery, reduced unnecessary inventory and improved material flow. The combination of these capabilities can therefore strengthen resource coordination and reduce waste.

This finding provides particularly strong support for Contingency Theory, because it demonstrates that the effectiveness of MRP is not completely independent of other operational practices. Instead, its contribution to sustainability performance can vary according to the extent to which it is complemented by JIT. It also supports RBV by suggesting that competitive advantages can arise from combining complementary capabilities rather than relying on individual resources in isolation (Barney, 1991). The result extends earlier research on MRP by demonstrating that its contribution to sustainability performance can be conditioned by another operational capability, namely JIT.

In contrast, JIT did not significantly moderate the relationship between Inventory Operation and sustainability performance ($\beta = 0.028$, $t = 0.627$, $p = 0.531$). Although the interaction coefficient was positive, it was statistically insignificant. This means that while Inventory Operation independently contributes to sustainability performance, the implementation of JIT does not significantly strengthen or weaken this relationship among the manufacturing SMEs examined. The finding is important because it demonstrates that a direct positive relationship does not automatically imply a significant moderating relationship.

The non-significant moderation may be explained by the operational conditions under which manufacturing SMEs in Bauchi State function. Effective JIT systems generally require reliable suppliers, predictable delivery times, accurate information, stable transportation and dependable production processes. Where these conditions are inconsistent, JIT may not generate sufficient additional value to significantly alter the relationship between inventory operations and

sustainability performance. This explanation is consistent with the contingency perspective, which emphasises that the effectiveness of an operational practice depends on its fit with organisational and environmental conditions (Donaldson, 2001; Donaldson, 2025).

Finally, the study reported that JIT moderates the relationship between Production Scheduling and sustainability performance, with an interaction coefficient of $\beta = 0.045$ and a reported p-value of 0.000. The finding suggests that production scheduling may produce greater sustainability benefits when supported by JIT practices. JIT can facilitate synchronisation between production activities and material availability, allowing firms to align production more closely with actual requirements. This finding is consistent with Chakraborty and Dey (2023), Goswami et al. (2024) and Tiwari et al. (2024), which emphasised the importance of production planning and scheduling for manufacturing performance. The present study extends this evidence by demonstrating the potential moderating role of JIT.

5. Conclusion and Recommendations

The study concludes that MRP, Inventory Operation and Production Scheduling significantly improve sustainability performance, with MRP having the strongest effect. JIT significantly strengthens the effects of MRP and Production Scheduling but does not significantly moderate Inventory Operation, indicating that its effectiveness depends on the operational context.

Manufacturing SMEs should strengthen Material Requirement Planning (MRP) through better material forecasting, procurement and resource coordination. They should also improve inventory control and production scheduling to reduce wastage, delays and unnecessary costs. JIT should be integrated with MRP and production scheduling, while inventory controls should be strengthened before adopting JIT extensively.

Contribution to Knowledge

The study contributes empirical evidence that MRP, Inventory Operation and Production Scheduling enhance SME sustainability performance. It further demonstrates

that JIT has a selective moderating effect, supporting the application of RBV and Contingency Theory.

Limitations

The study focused on manufacturing SMEs in Bauchi State and used a cross-sectional design and self-reported data. These factors may limit the generalisability of the findings.

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Suggestions for Further Studies

Future studies should examine other states and sectors, use longitudinal or mixed-method approaches, and include additional factors such as technology, supply chain agility, supplier reliability and environmental uncertainty.

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