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EFFECT OF ENVIRONMENTAL SUSTAINABILITY PRACTICES ON INNOVATION DEVELOPMENT OF LISTED MANUFACTURING FIRMS IN NIGERIA

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ABSTRACT

Material and waste management practices are critical components of environmental sustainability practices, particularly in the manufacturing sector. This study examined how these practices drive innovation among Nigerian manufacturing firms, focusing on their impact on research and development (R&D) expenditures. Using secondary data from the 2013 – 2023 annual reports of 38 listed manufacturing firms sampled in this research, the study investigated the role of effective material utilization, recycling, and waste reduction strategies in fostering innovation. The findings suggest that firms that integrate sustainable material and waste management practices achieve significant improvements in product innovation and operational efficiency. The study recommends that Implementing Just-In-Time (JIT) inventory practice can help manufacturing firms reduce excess inventory holding costs while ensuring that the necessary materials are available when needed for research and development projects. Moreso, embracing lean manufacturing principles can help manufacturing firms identify and eliminate waste throughout the production process and support sustainable industrial practices.

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Key words: *Environmental Sustainability Practices, Innovation Development, Material Management Practice, Research and Development Expenditures, Waste Management Practices*

1. INTRODUCTION

In recent times, progress and element of innovation are pari passu. Research and development, as an element of innovation development, is one of the essentials for growth and progress of any manufacturing firm. Innovative development of manufacturing firms is therefore an indispensable aspect and well recognized. Some manufacturing firms are subject of extolment today as their conventional mode of production are being modified to environmentally

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friendly, sustainable and ecological pattern of production. The focus is towards healthy and sustainable way of life, to limit the impact of manufacturing activities on the environment and to achieve a better performance. Furthermore, there are laid down environmental policies, measures, targets for carbon emissions, energy usage, waste and resources management and environmental standards by government to achieve this environmental sustainability and to make the practice work. The manufacturing sector is a key driver of economic growth, yet it significantly contributes to environmental degradation. Accordingly, sustainable material and waste management practices have emerged as strategic approaches to mitigate environmental impact while fostering innovation. Prior studies proved that the implementation of environmental sustainability practices is associated with an increase in production cost as a result of additional cost incurred in environmental sustainability and risk of being subjected to sanctions and fine (Ramayah & Rahbar, 2013; Siswoyo, Kustyadji, Wijayani & Hartati, 2020; Yasmeen & Raksha, 2022; Ahmed, Akbar, Aijaz, Channer, Ahmed & Parmer, 2023). These made companies reluctant in implementing environmental sustainability practices. Lamenting further, Agarwal, Chaudhary and Singh (2015) submitted that companies are expected to go beyond the financial focus and extend into an encompassing economic, environmental, and social sustainability by vigorously pursuing investment in electronic waste discarded devices, and developing strategies on how to improve material usage in a manner that positively impacts the environment in which it exists. For instance, organisations can switch to reusable products to reduce its dependency on single-use products. Therefore, material and waste management practices are critical components of environmental sustainability practices particularly in the manufacturing sector.

1.1 Objectives

The main objective of the study is to ascertain the effect of environmental sustainability practice on innovation development of listed manufacturing firms in Nigeria. Specifically, the study intends to:

1. ascertain the effect of material management practice on research and development (R & D) innovation expenditures and cost incurred on machines for the process and production of new products of listed manufacturing firms in Nigeria.
2. determine the effect of waste management practice on research and development (R & D) innovation expenditures and cost incurred on machines for the process and production of new products of listed manufacturing firms in Nigeria.

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1.2 Hypotheses

Based on the above objectives, the following hypotheses will guide the study. The hypotheses are stated below in null form:

H_{o1}: Material management practice does not have significant effect on research and development (R & D) innovation expenditures and cost incurred on machines for the process and production of new products of listed manufacturing firms in Nigeria.

H_{o2}: Waste management practice does not have a significant effect on research and development (R & D) innovation expenditures and cost incurred on machines for the process and production of new products of listed manufacturing firms in Nigeria.

2. LITERATURE REVIEW

2.1 Conceptual Review

2.1.1 Concept of Environmental Sustainability Practices

Defining environmental sustainability practices is crucial to establish a clear understanding of what constitutes the practices (Tennakoon & Janadari, 2021). Sustainability in a broad sense refers to the ability to maintain or support a process continuously over a period of time. In business context, it is the ability of an organization to be able to endure and maintain itself environmentally, economically and socially to avoid depleting or degeneration of natural resources enabling a long-term environmental quality, meeting the needs of today's population without compromising the future generation's ability to meet their needs. Environmental sustainability practices are social practices that give adequate protection of the environment in which the business operates. These are practices that encompasses a wide range of actions, policies, and strategies aimed at mitigating environmental impact, conserving resources, and promoting sustainable development. They include efforts to reduce carbon emissions, conserve water, minimize waste, and protect ecosystems (Noiki, Salawa, Afolalu, Kayode & Lawal 2023). Understanding the impact of environmental sustainability practices is a complex task due to the multifaceted nature of sustainability itself (Getzler & Mathers, 2022). Environmental Sustainability is about expanding the financial bottom line into a triple bottom line, which includes environmental, economic, and social aspects of corporate performance, this is to say that there are three dimensions of sustainability which suggests that business goals are inseparable from the societies and environments within which they operate (Zubir & Habidin, 2012; Albertini, 2013).

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Economic sustainability is the duty of businesses and the community in which it exists. It is the ability to generate enough capital flow to ensure liquidity and to produce a persistent return for the long-term (Bruno, 2018). In essence, Organisations are to responsibly and efficiently use their resources to complement long-term economic growth without harming any aspect of the community. Social sustainability on the other hand is to the advantage of the people. It is enhanced when an organisation by all means preserves skills, ensuring health and well-being of people within and outside its territory. The effort of the organisation in the course of their operation will be to ensure that the people stay safe, live sustainably as individuals, families, communities and the country. Slack et al. (2013), reported that as much as sustainable business permits business owners to make profit, it ensures that damage to the environment and the people in environs is reduced to the nearest minimum. Environmental sustainability pay attention on the state of the planet we leave in. it encourages individual and businesses to generate minimal waste and regenerates some of the resources use. It is the policies and actions taken by firms in order to promote sustainability of the natural environment (Aguinis & Glavas, 2012; Hartmann & Uhlenbruck, 2015). The main focus of environmental sustainability is in the management of organizations, working conditions of employees and the quality of operational processes related to the economic, social and environmental aspects of sustainable development (Zhu et el, 2018). Environmental sustainability practice encompasses all organisational activities from raw materials, production processes, and packaging to environmentally friendly waste disposal. It improves waste treatment and reduces resource consumption.

Companies are eager to consider the environmental sustainability practice principles as a result of its benefits. These makes them to be involve in a process of social responsibility. They identify and recognises roles they can play in the three dimensions of sustainability to foster a more equitable distribution of wealth, social equity and environmental preservation (ElGammal, El-Kassar, Canaan & Messarra, 2018; Al-Abdin, Roy & Nicholson 2018). Environmental sustainability practices in environmental management are vital in reducing the negative impact of production activities on the environment. To attain environmental sustainability, there must be an implementation of environmental management to arrest environmental and developmental challenges. It is a way of creating a long-time stakeholder value by putting into practice a business strategy that assign some quality to every dimension on how a business operates in the ethical, social, environment, cultural and economic globe. It recognises the growth and profit of an organisation as well as requiring such an organisation

to pursue societal goals especially those that relate to sustainable development (Wilson, 2003). Sustainability can also be defined as an all-embracing conceptual framework that describes a desirable, healthy, and dynamic balance between human and natural systems, a system of policies and practices that will protect the differences and richness of the planet's ecosystems, nurture economic vitality and opportunity, and create a high quality of life for people. It is a vision describing a future that anyone would want to inhabit (Amos &Uniamikogbo, 2016). Summarily, sustainability is the commitment of an organization to sustain, support, uphold and in a way contribute to the economic, environment and social life of those around its existence. The emerging environmental issues constitute a trigger for organisations to find alternative means to survive. To succeed in the dynamic business environment, there must be an implementing sustainable practice (Chang et al, 2018; Saudi et al, 2019). Environmental sustainability practices are the practices exhibited by organisations while carrying on their activities to maintain an ecological balance.

2.1.2 Material Management Practice

Material management refers to the strategic planning, coordination, and control of activities involved in the procurement, storage, handling, and movement of materials within a manufacturing company's supply chain. It is aimed at managing the quality, sourcing, price, location, and movement of raw materials used in production (Kuuse, 2023). Implementing effective materials management practices can have several benefits, including improved control over the supply chain, cost reduction, improved cash flow, increased efficiency, and better product quality. Environmental material management refers to the practices and strategies implemented to minimise the environmental impact of materials throughout their life-cycle. It involves using resources more efficiently, reducing waste generation, and considering the environmental implications of material use and disposal (U.S. EPA, 2023a). Material management practice enables businesses to gain more control over their material management processes, leading to improved efficiency, cost savings, and customer satisfaction. Environmental material management is a systematic approach that focuses on using and reusing materials more productively over their entire life cycle. It involves using materials in the most productive way, reducing toxic chemicals and environmental impacts, and ensuring sufficient resources for present and future needs. This can guide decision-making to minimise environmental impacts and identify opportunities for improvement which can lead to the development of innovative solutions and continuous improvement. Environmental management practices ensure that businesses effectively manage materials in

a way that reduces environmental harm, conserves resources, and promotes sustainability. This significantly contributes to cost savings and enhances the company's reputation as a responsible and environmentally conscious organization.

i. Material management practice typically involves several key steps which includes;
ii. Forecasting: this involves using historical data and others tools to predict future demands for materials. This also helps organisations to plan their inventory levels and avoid stock-outs or overstocking.
iii. Procurement; this involves sourcing materials from suppliers and negotiating contracts and pricing. The goal is to obtain the materials needed at the best possible price and delivery terms.
iv. Inventory management; this involves tracking and controlling the flow of materials, monitoring stock levels, managing stock replenishment and implementing inventory control system to minimise waste and maximise efficiency within the organisation.
v. Distribution; this entails the movement of materials from the point of production or receipt to the point of use. The effectiveness of this aspect of material management practices may involve using warehouses, distribution centers or other logistic facilities to store and distribute materials efficiently.
vi. Reverse logistics; this is about managing the return of materials to suppliers, manufacturers or other parties to minimise waste and maximise the value of the materials.

In summary, effective material management practices can help organisations reduce costs, improve efficiency and enhance customer satisfaction. These practices are widely used in a variety of industries including manufacturing, retail, healthcare and military logistics.

2.1.3 Waste Management Practice

waste is any material which is not needed by the owner, producer or processor. It is often referred to as any material or substance generated and disposed of, intended to be abandoned by such persons responsible for its oversight. It can be defined as the unwanted by-products of human activities, product life cycle and is disposed of in landfills (Agarwal, Chaudhary and Singh 2015). It is necessary that such materials or substances be managed this is because effective waste management is one of the most crucial aspects of sustainable development. Igbinomwanhia (2011) in his terms assumed that waste management encompasses the utilisation of a planned amalgamation of methodologies to efficiently transfer trash from its origin to its final disposal location, to sustain a secure condition while minimising costs.

World Commission on Environment and Development (1987), in their address present the needs for waste management without jeopardising future generations' capacity for self-sufficiency. Therefore, effective waste management in urban areas is of the utmost importance. Fan, Abbas, Zhong, Pawar, Adam and Alarif (2023) stated that the effects of waste disposal activities may extend beyond the immediate jurisdiction and affect future generations; hence, a sustainable urban system must adhere to the principles of resource consumption not exceeding resource generation and waste generation not exceeding the ecosystem's capacity to assimilate it. In lieu of this, urban waste is frequently transported to other regions for processing and treatment as materials. Waste management practice shows significant variation across different countries. They are aimed at reducing the environmental impact of waste generated from various sources. It involves using materials in the most productive way, reducing toxic chemicals and environmental impacts, and ensuring sufficient resources for present and future needs. Proper waste segregation is essential to enhance resource recovery. It involves separating waste into different categories such as recyclables, organic waste, hazardous waste, and non-recyclables.

Waste reduction involves modifying current practices to reduce the amount of waste generated. This can be achieved by changing the design, manufacture, purchase, or use of products. According to the Intergovernmental Panel on Climate Change (IPCC), (2022) municipal solid waste is expected to reach approximately 3.4 Gt by 2050. Abila, Abila and Kantola (2023) examined the issues surrounding municipal solid waste management in Nigeria and presented a comprehensive analysis of the difficulties associated with it. A theoretical framework was proposed for knowledge management that could potentially address the problem of municipal waste in urban areas across the country. They stated further that implementing a knowledge management strategy and methodology is essential for promoting a paradigm shift toward enhancing waste management practice.

In the Nigerian context, the provision of waste management services is predominantly the responsibility of local governments and private sector entities (Adedigba, 2022). but Mihai, Gundogdu, Markley, Olivelli,Khan, Givinnett, and Molinos_senante (2022) suggested that Individuals, households, consumers, and waste management companies should engage in waste management services. Stating further that inefficient waste management is attributed to insufficient awareness of the benefits of proper waste management and ineffective enforcement of government regulations which has led to inadequate management and

administration of solid waste, indiscriminate dumping, and a lack of acceptable disposal sites which in turns poses significant challenges to residents (Kamaruddin & Muhammed, 2022). Measures of waste management include measures for integrated techno-economic mechanisms of a circular economy, effective disposal facilities, export and import control and optimal sustainable design of products that are produced (Gollakota, Gautam, & Shu, 2020).

2.1.4 Innovation Development

Development is a broad concept and is subjectively defined depending from the angle it is being viewed; this is due to the different interpretation given to it by different experts and researchers. innovation on the other hand has been a phenomenon that serves a single purpose: to make life more comfortable for humans (Kotsemir & Meissner, 2013). In addition to this ideology, Leiponen and Helfat (2010) argue that many times the innovation contributes to the survival of not only individuals but also organizations as a whole. They stated further that if organisation takes this innovation process, it reflects their competencies, renew their competitive vigor and contribute to the longevity such organisation. In developing innovation, it is necessary to develop management systems, which is knowledge, which can be applied for use of organizational resources allowing a new production process (Musiolik, Markard, & Hekkert, 2012). Innovation development process varies, being influenced by so many factors which include the sector of activity or by the size of the company. Innovation development is the process of applying digital product engineering to a business's innovation goals, thereby bringing innovative ideas into reality. It requires all activities involved in turning a concept for new and better user experiences into real-world products. Innovativeness is the degree to which an organization implements new ideas or technology in relation to their competitors to gain competitive advantages relative to time, cost and efficiency.

Innovation is making idea, invention of goods and designing a new process of services that create enough value for customers to want to buy. Innovation also propitiates a new opportunity to influence the market direction in which the organization is inserted by different attributes developed in marketed products, which represent a new business perspective (Schreiber & Bohrer, 2014). It is anything that suggests an alternative to something that is done in a certain way, anything that brings economic and behavioral benefits, solves problems, or makes people's daily lives more practical. Creating unique products and services and getting them to market before competitors, can benefit a company. Therefore, the term innovation includes new technological, economic, social and organizational solutions that are

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not necessarily marketable, in the economic sense and direct monetary impact, but are applicable and are being used within organizations (Fabian, Edson, Araujo & Marcela, 2016). To innovate is to go beyond expectations of stakeholders and the market. For this to happen, speed quality and precision are the needed criteria. It can be related to a product, service, process, market, and means of production, technology or anything else that brings about a change that becomes sustained and indispensable.

2.2 Theoretical Review

2.2.1 Resource Based View (RBV) Theory

The Resource Based View (RBV) is a management framework that focuses on the internal resources and capabilities of an organisation as sources of competitive advantage. The RBV has been widely used in studies of firms when measuring sustainability and competitive advantage, as they are achievable by understanding the optimal utilization of scarce and inimitable organisational resources (Barney, 1991; Gile et al., 2018), making it suitable for this research. RBV suggests that a firm's unique bundle of resources, such as physical assets, human capital, technology, reputation, and organisational culture, determine its ability to create and sustain a competitive edge. Thus, the theory focuses on internal resources and emphasizes that those resources can help formulate strategies for achieving targets, such as sustainability (Madhani, 2009). RBV emphasizes that not all resources are equally valuable or rare. Valuable resources enable firms to exploit opportunities or mitigate threats, while rare resources are those that are not easily available to competitors. Additionally, the framework considers resources that are difficult to imitate or replicate by rivals, known as inimitable resources, as another key element for creating a sustained competitive advantage. According to RBV, organizations should continuously assess their resources, identify those that are valuable, rare, and inimitable, and leverage them to achieve superior performance. RBV argues that managers of businesses should perform an in-depth internal study of their resources and skills, identifying their strengths and shortcomings and matching them with market opportunities and threats.

2.3 Empirical Review

Tennakoon, Janadari and Wattuhewa (2024) studied Environmental sustainability practices: A systematic literature review carried out in SRI LANKA. In their systematic literature review explored the evolution and significance of environmental sustainability practices from 2010 to 2023. Through this exploration, they uncovered discernible patterns, emerging trends, and

valuable insights that shed light on the trajectory of these practices and their far-reaching consequences for environmental conservation and sustainable development. The review highlights the growing awareness of ecological sustainability by using a four-step technique to select 351 papers. Their key findings underscored the critical role of multidisciplinary collaboration, data-driven decision-making, and adaptive management strategies in advancing environmental sustainability practices.

Peter, iyobhebhe and salihu (2023). Investigated waste management administration and environmental sustainability in Nigeria with variables like waste disposal, waste separation, waste management and waste recycling using a linear regression to determine the Anova and coefficient result of the questionnaire revealed a negative correlation between waste management agency operations and environmental sustainability as well as between waste disposal, waste separation and environmental cleanliness.

Khan, Yu and Farooq (2023), in their research on Green Capabilities, Green Purchasing, and Triple Bottom Line Performance: Leading toward Environmental Sustainability in China recognized a vast literature on green purchasing practices and sustainability and the role of an organization's green capabilities in defining green purchasing practices for triple-bottom-line performance but with limited attention. This research empirically evaluated the impact of green capabilities on green purchasing practices to boost the triple-bottom-line performance of manufacturing organizations. they analyzed 386 manufacturing organizations' responses using the covariance-based structural equation modeling approach. The results indicated a positive correlation between green capabilities and purchasing habits; however, green innovation capabilities did not establish a statistically meaningful correlation. Additionally, green buying strategies have significant favorable associations with the triple bottom line of performance.

Gloria and Ebele (2023) studied the role of Research & Development (R&D) investment on economic transformation in Nigeria They investigated the role of Research and Development (R&D) investment (expenditure) in Nigeria’s economic transformation process in the 32-year period from 1990 to 2021, using the ARDL modeling technique, where variables may have a long-term relationship but may also exhibit short-term dynamics. The study found that R&D expenditures have a positive relationship with the export diversification index (EDI), which is a trade-based measure of economic transformation, although the impact is not statistically

significant, thus indicating a weak relationship between R&D expenditure and economic transformation. It also revealed that the control variables: ALR (adult literacy rate - used to proxy human capital development) has a positive relationship with the EDI in the second lagged period, and CRP (credit to the private sector as a percentage of GDP), and FDI (foreign direct investment stock as a percentage of GDP) have positive relationships with the EDI in the current and second lagged periods, thus implying positive impacts on economic transformation.

Qalati, Barbosa and Iqbal (2023). Studied The effect of firms' environmentally sustainable practices on economic performance in China. They realized that Companies are pressured by stakeholders to protect the environment while improving their economic performance. The study further explores the impact of environmentally sustainable practices (ESP) on firm performance (FP), by considering the effects of green employee integration (GEI), environmental sustainability (ES), and employee environmental orientation (EEO). a closed-ended questionnaire survey was conducted with employees working in the manufacturing sector in China to test their hypotheses. Data from 325 employees were analysed using SmartPLS 4 software. The results demonstrated that environmentally sustainable practices (ESP) have a direct and significant influence on GEI, ES, and FP. In addition, GEI has a significant direct impact on ES and FP, and ES has a direct impact on FP.

Ruohan (2023). In his work titled Environmental management, environmental innovation, and productivity growth: a global firm-level investigation empirically investigated the economic effects of environmental activities in 41 countries. He investigated the interactive influence of firms' environmental management and environmental innovation on their productivity considering both internal and external environmental management practices of global firms observed from the 41 countries between 2017 and 2019. he also considered both inputs and outputs of firms' innovation activities that aim to reduce environmental impacts. Using a semi-parametric method, he found that environmental management and environmental innovation are directly correlated to each other and both substantially promote productivity; however, they tend to substitute each other's positive effects on productivity. Other variables such as globalisation, government, labor inputs, and informal competition strongly affect firm productivity too.

Kamaruddin and Muhammed (2022) carried out a study on solid waste management and disposal practices in Bauchi City, Nigeria. Their findings indicated lack of awareness and ignorance of solid waste management practices and insufficient waste facilities, lack of materials and waste equipment. Management Practice in the Global South. This study assesses the human and environmental health impacts of Solid Waste Management (SWM) practices in the Global South cities that are the future of global urbanization by employing desktop research methodology based on in-depth analysis of secondary data and literature, including official documents and published articles. They found out that the common SWM practices include mixing household and commercial garbage with hazardous waste during storage and handling. While waste storage is largely in old or poorly managed facilities such as storage containers, the transportation system is often deficient and informal. The disposal methods are predominantly via uncontrolled dumping, open-air incinerators, and landfills. The negative impacts of such practices include air and water pollution, land degradation, emissions of methane and hazardous leachate, and climate change. These impacts impose significant environmental and public health costs on residents with marginalized social groups mostly affected.

Andersen (2021), in his study titled A relational natural-resource-based view on product innovation: The influence of green product innovation and green suppliers on differentiation advantage in small manufacturing firms in Sweden. Explained how the resource-based view (RBV) of the firm has been used to examine the role of resources and capabilities in product innovation and how product innovation is related to overall firm performance. Using data from 305 Swedish small manufacturing firms, structural equation modeling he examined the relationships between green product innovation (GPI), differentiation advantage and firm performance, and how these relationships are influenced by a relational resource in terms of green suppliers. The results demonstrate that GPI affects differentiation advantage and that this relationship is strengthened by having green suppliers. The article offers a RNRBV on product innovation and illustrates the importance of incorporating additional dependent variables other than aggregated performance measures when researching GPI. Moreover, the study shows that green suppliers can provide important products and complementary resources in order for the focal firm to fully realize its GPI capability.

Obamen, Omonona, Oni and Ohunyeye (2021) in their work titled Effect of Environmental Management Practices and Sustainability on Some Selected Manufacturing Firms in South

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East Nigeria investigated the effect of environmental management practice tools on the sustainability of manufacturing organizations. The goal of the study was to determine the relationship between environmental management practice tools and sustainability. A survey design was used for this study. A total of 363 questionnaires were distributed to the employees of the manufacturing firms, which included managers, supervisors, and line staff. The data collected were analyzed using Principal Component Analysis (PCA). Primarily, the study established that environmental management practice tools were significantly and positively related to sustainability. Thus, the study concluded that environmental management practice tools contribute significantly and positively to firms' social, economic, and environmental sustainability. Additionally, the result of this study underlines the significance to manufacturing firms of carrying out environmental management practices.

3. MATERIALS AND METHOD

The study adopted the quasi- experiment. The population of the study comprises of all the 54 manufacturing firms that are listed on the floor of the Nigerian Exchange Group (NGX) as at 2023. Purposive sampling was used to adopt thirty-eight (38) companies across the listed manufacturing firms based on the availability of financial statement. The listed manufacturing firms were sampled for a period of ten years covering year 2013 – 2023. Secondary data collected from their financial report and was analysed using descriptive statistics, correlation and regression analysis. The dependent variable innovation development was proxy with research and development innovation expenditure (Total funds committed to R&D scaled by total assets for firm I at time t) while the independent variables are: material management practice (Natural logarithm of cost incurred in the procurement of machines), waste management practice (Dummy variable, 0 if not disclosed and 1 if disclosed based on GRI).

In order to estimate the model and examine the proposed hypotheses, the following regression model were estimated:

RDE = f (MMP, WMP, FS) ……. Eqn 1.

The model is stated explicitly as follows:

$RDE_{it} = \alpha_0 + \beta_1 MMP_{it} + \beta_2 WMP_{it} + \beta_3 FS_{it} + \varepsilon$……Eqn 2

Where:

RDE - Research & Development (R & D) Innovation Expenditures;

MMP - Material Management Practice

WMP - Waste Management Practice

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FS - Firm Size.

$\beta_1 - \beta_3$ -represent the coefficient of the explanatory variables.

i - denote the number of firm in the panel.

t - denote the time period of the panel data.

ε - the error term.

Accept the alternate hypothesis if p-value is less than 0.05, otherwise reject the null hypotheses

4. RESULT AND DISCUSSIONS

4.1 Data Analysis

4.1.1 Descriptive Analysis of Data

The descriptive statistics was used to evaluate the characteristics of the data: mean maximum, minimum, and standard deviation and also check for normality of variables and to check for multi-collinearity, variance inflation factor analysis was conducted to confirm the multi-collinearity result. Multiple regression analysis was used to evaluate the effect of the independent variables on the dependent variable to reveal and predict the degree of effect the independent variables have on the dependent variables. Accept the alternate hypothesis if p-value is less than 0.05, otherwise reject the null hypotheses

Table 1 Descriptive statistics of dependent, independent and control variable

	RDE	MMP	WMP	FS
Mean	2.34E+08	89975263	0.306954	1.44E+08
Median	1.13E+08	8074000.	0.000000	61121470
Maximum	1.63E+09	1.01E+09	1.000000	9.96E+08
Minimum	10000000	0.000000	0.000000	10000000
Std. Dev.	2.80E+08	1.91E+08	0.461784	2.01E+08
Skewness	1.976204	2.847151	0.837090	2.293590
Kurtosis	7.105081	10.97787	1.700719	7.806042
Jarque-Bera	564.2221	1669.241	78.03125	766.9370
Probability	0.000000	0.000000	0.000000	0.000000
Sum	9.77E+10	3.75E+10	128.0000	6.02E+10
Sum Sq. Dev.	3.26E+19	1.52E+19	88.70983	1.68E+19
Observations	417	417	417	417

Source: E-Views 11

Key: RDE- Research & Development (R & D) Innovation Expenditures; MMP-Material Management Practices; WMP-Waste Management Practice and FS-Firm Size.

RDE is the amount of money firms allocate to research and development activities. The mean of RDE is 2.34E+08 and the median value of 1.13E+08. The high mean (2.34E+08) and large standard deviation (2.80E+08) indicate substantial variation in R&D spending among firms. Firms with higher R&D expenditures are likely investing heavily in innovation to gain a competitive edge. The significant skewness (1.976204) and high kurtosis (7.105081) suggest a few firms invest exceptionally large amounts in R&D, possibly indicating industry leaders or highly innovative firms.

MMP measures the extent to which firms implement practice to manage materials efficiently. The mean of Material Management Practice (i.e., MMP) is 89,975,263 and the Median value is 8,074,000. The mean value suggests that some firms are investing significantly in these practices, but the large standard deviation (1.91E+08) and median (8074000) indicate most firms spend much less. There is a wide range in the adoption of material management practice, with a few firms leading the way. The positive skewness (2.847151) and high kurtosis (10.97787) indicate that while many firms might have minimal or no investment in MMP, a few are investing heavily.

WMP indicates whether firms have implemented waste management practice, with values generally between 0 (no implementation) and 1 (full implementation). The mean value of WMP is 0.306954; and, the median value was 0.00. The mean shows that on average, firms are moderately engaged in waste management. The low median (0) and the high standard deviation (0.461784) suggest that many firms have not adopted waste management practice extensively. However, the positive skewness (0.837090) implies a growing interest or pressure to adopt these practices.

The average value of Firm Size (i.e., FS) is 1.44E+08; while, the median value was 61121470. The high mean and large standard deviation (2.01E+08) show considerable variation in firm sizes. The Skewness value was positive 2.293590; and the Kurtosis value of 7.806042. The significant skewness and high kurtosis suggest that a few very large firms might skew the distribution. The analytical results confirm a right-skewed distribution, where the majority of firms have lower R&D expenditures, and a few firms have significantly higher expenditures. This aligns with the skewness value (1.976204) reported in the summary statistics. The

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highest frequency occurs in the lower range of R&D expenditures, specifically between 0 and 200,000,000. This suggests that most firms spend relatively modest amounts on R&D. As R&D expenditures increase, the frequency of firms decreases, indicating fewer firms allocate large sums to R&D. The concentration of firms in the lower expenditure range suggests that while many firms invest in R&D, only a few make substantial investments. This could imply a strategic focus on R&D among a small number of leading firms.

Table 2 Correlation analysis of dependent, independent and control variable

	RDE	**MMP**	**WMP**	**FS**
RDE	1.0000			
MMP	0.6962	1.0000		
WMP	0.0180	0.0978	1.0000	
FS	0.7303	0.0181	-0.0679	1.0000

Source: E-Views 11

Key: RDE- Research & Development (R & D) Innovation Expenditures; MMP-Material Management Practices; WMP-Waste Management Practices; FS-Firm Size.

The provided the Pearson correlation coefficient matrix of the variables. The coefficients range from -1 to 1, indicating the strength and direction of the linear relationship between the variables. RDE positively correlated with MMP 0.6962; suggesting that firms with higher R&D expenditures also tend to invest more in MMP.

4.2 Test of Hypotheses

Table 3 Regression Analysis Result

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.270322	0.167351	1.615293	0.1073
MMP	0.361629	0.015356	23.54904	0.0000
WMP	-0.005888	0.058474	-0.100694	0.9199
FS	0.663179	0.024912	26.62132	0.0000

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4.2.1 Hypothesis One

H_{o1}: Material management practice does not have significant effect on research and development (R & D) innovation expenditures and cost incurred on machines of listed manufacturing firms in Nigeria.

Looking at Table 3, the t-statistic of MMP is 23.54904; which is highly significant positive effect on R&D expenditures. This indicates that better material management practice is strongly associated with increased R&D spending. Since the p-value is 0.0000 is less than .05; we reject the null and accept the alternate: material management practice does not have significant effect on research and development (R & D) innovation expenditures and cost incurred on machines of listed manufacturing firms in Nigeria.

Paul and Lopez (2022) found that environmental management practices positively influence technological innovation performance in manufacturing firms. Specifically, their study highlighted how effective environmental management and supply chain integration enhance firms' capabilities for innovation. Zhang and Ma (2021) explored the impact of environmental management on firm economic performance, emphasizing green innovation as a mediator between environmental management practices and economic outcomes. El Kassar and Singh (2019) examined the role of big data, management commitment, and HR practices in enhancing the competitive advantage, economic, and environmental performance of firms through green innovation. Their study, involving a sample of 215 respondents from the MENA region and GCC countries, found that green innovation, including efficient material management, significantly improves organizational performance by reducing energy consumption and waste. This highlights the importance of integrating advanced data analytics and robust management practices to optimize material usage and drive innovation in manufacturing firms. Ukpabio, Siyanbola, and Oyebisi (2017) investigated the impact of technological innovation on the performance of manufacturing firms in Nigeria, focusing on 305 SMEs across various subsectors. Their findings revealed a significant positive relationship between product and process innovation and firm performance, suggesting that effective material management practices can enhance R&D innovation expenditures and overall productivity.

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4.2.2 Hypothesis Two

H_{o2}: Waste management practice does not have a significant effect on research and development (R & D) innovation expenditures and cost incurred on machines of listed manufacturing firms in Nigeria.

Deducing from Table 3, the t-statistic of WMP is -0.100694; is highly not significant negative effect on R&D expenditures. Since the p-value is 0.0000 is greater than .05; we reject the alternate and accept the null: waste management practice does not have a significant effect on research and development (R & D) innovation expenditures and cost incurred on machines of listed manufacturing firms in Nigeria.

Chege and Wang (2020) investigated the influence of technology innovation on SME performance through environmental sustainability practices, suggesting that effective waste management practices contribute to improved company performance and sustainability. Abubakar et al. (2022) studied the environmental sustainability impacts of solid waste management practices in the Global South, focusing on how effective SWM practices can mitigate environmental and public health risks.

Dieste et al. (2019) conducted a systematic literature review to explore the relationship between lean production principles and environmental performance. Their findings, summarized in a matrix linking lean practices to environmental measures, indicated that lean practices focusing on waste reduction can improve environmental performance. Obamen et al. (2019) examined the effects of environmental management practices on the sustainability of multinational companies in South-South Nigeria. Their literature-based study concluded that quality management practices positively affect economic sustainability, while green technologies enhance social-environmental sustainability.

5. CONCLUSION AND RECOMMENDATIONS

The study examined the effect of environmental sustainability practices on innovation development of listed manufacturing firms in Nigeria. Using a sample of thirty-eight firms from the manufacturing industry, i.e., consumer goods, industrial goods, agriculture, across environmentally sensitive industry. The study finds a significant positive effect of material management practice on research and development (R & D) innovation expenditures no significant effect of waste management practice on research and development (R & D) innovation expenditures. This implies that when material management practice is effectively

carried out in a manufacturing firm, it can contribute to further investment in research and development (R & D) innovation expenditures thereby fostering the advancement in innovation of new product and production processes, improved efficiency and better utilization of resources. it also establishes that the practice of waste management alone cannot be an influencing factor to innovation development rather it is telling us that there are other factors that need to be directly considered while making decisions about R&D innovation expenditures. We should note likewise that waste management practices sure have other indirect benefits for the organization.

It was therefore recommended that, manufacturing firms should

1. adopt Just-In-Time (JIT) Inventory Management: Implementing JIT inventory practice can help manufacturing firms reduce excess inventory holding costs while ensuring that the necessary materials are available when needed for R&D projects. This can lead to a more streamlined and efficient R&D process, resulting in cost savings and increased innovation capabilities.
2. implement Lean Manufacturing Principles: Embracing lean manufacturing principles can help manufacturing firms identify and eliminate waste throughout the production process. Thus, from minimizing non-value-added activities, optimizing resource utilization, and streamlining operations, firms can reduce waste generation and associated costs while enhancing their capacity for innovation in R&D projects. Secondly, conducting Regular waste audits and analyses offer valuable insights into the types and quantities of waste generated during the manufacturing process. Therefore, pinpointing areas of waste generation and identifying opportunities for improvement, firms can develop targeted strategies to minimize waste, recycle materials, and optimize resource utilization. This not only reduces costs but also supports R&D innovation initiatives.

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