

## ENVIRONMENTAL POLICY, RECYCLING AND SUSTAINABLE PERFORMANCE OF MANUFACTURING FIRMS IN NIGERIA

*Timinepere Ogele COURT, PhD*  
*Department of Business Administration*  
*University of Africa, Toru-Orua, Nigeria*  
*Email: [timinepere.court@gmail.com](mailto:timinepere.court@gmail.com)*  
*[timinepere.court@uat.edu.ng](mailto:timinepere.court@uat.edu.ng)*  
*<http://orcid.org/0000-0001-8731-2047>*

<https://doi.org/10.70118/ajbam-02-2025-113>

---

### ABSTRACT

There is great concern for sustainable development to ensure that the future of unborn generations is not sacrificed for the market model of profit maximization by firms. Prior studies have investigated the attitude of individuals towards recycling, firms' green supply chain management, and sustainable performance. However, how public environmental policy influenced recycling of waste materials at the firm level and the mediation of recycling between environmental policy regimes and the triple bottom line of economic, social and environmental performance have not been adequately examined and this is the focus of this paper. The study adopted an analytical survey design. A sample of 174 managers was selected through a stratified sampling procedures and data were collected through the distribution and retrieval of a structured questionnaire. The data were analysed using structural equation modelling with Smart PLS software version 4.1.2. The result indicated that there was a positive relationship between environmental policy and recycling of waste materials; there was a positive relationship between recycling and sustainable social and environmental performance of manufacturing firms. The paper concluded that recycling waste materials not only reduced costs associated with production but also brought about eco-efficiency and sustainable performance. The paper recommended that managers of manufacturing firms should invest in recycling systems with eco-design and reverse logistic architecture.

**Keywords:** *Environmental policy, recycling, sustainable performance, manufacturing firms*

---

### INTRODUCTION

The realization of sustainable goals is of utmost interest among communities of nations (Akuma et al., 2024). From the Sustainable Development Report [SDR] (2023), Nigeria was ranked 146 out of 163 countries of the world while the regional average stood at 54.3% in the sub-Saharan Africa. According to Ebekozi et al (2022), Kalu and Origbakpor (2024), Njoku and Nwodeh (2024), tons of urban waste are generated in metropolises, and reliable policy structures, efficient waste management systems and skills to address waste-related challenges to attain sustainable cities and development goals appear to be a far-cry in Nigeria and developing countries in Africa. With the

United Nations directive of national governments to promote and pursue sustainable production and consumption behaviour (Sasmoko, 2022), corporate organisations, across the globe and in Nigeria, have to seek sustainable performance which is an appropriate mix of economic, social and environmental performance and this has been a fundamental objective of manufacturing firms for decades (Ogbeibu et al., 2024; Lawal, Igbekoyi, & Dagunduro, 2024; Chardine-Baumann & Botta-Genoulaz, 2014; Niesten et al., 2017).

Sustainable performance is the strategic capability of firms in minimizing negative ecological impacts

while pursuing and attaining a balanced economic, social and environmental goals. The pursuit of sustainable performance by firms is largely due to the waves of environmental issues such as global warming, climate change, resource depletion and pollution confronting the wellbeing of the ecosystem and society (Adekunle & Dakare, 2020; Ojala, 2007 and Relph, 2016). Recycling consists of firm practices of collection, processing of waste for re-use purposes and manufacturing new products. Recycling promotes resource conservation, waste reduction and cost minimisation in the creation of new products.

Accordingly, manufacturing firms engage in recycling of industrial waste of metals, glass, steel, tin and plastic cans and cardboard papers as an environmental conscious behaviour to mitigate pollution through disposition management in reverse logistic, which is built into eco-design architecture (Başaran, 2013). With the focus to attain sustainable development, recycling has attracted attention of managers in setting green strategic intent (Li, Liu, & Wang, 2010), scholarly conversation and debates among academics, pro-environmentalist, institutions and other set of stakeholders (Başaran, 2013; Mwanza, Mbohwa, & Telukdarie, 2018). Therefore, eco-legal and eco-institutional frameworks have been formulated to address the menace of environmental injustice and degradation. The Government of Nigeria enacted pro-environmental policies and established institutions which engender manufacturing firms in pursuit of sustainable development and triple bottom line at the firm level (Adeoti, 2008; Chokor, 1993).

The study is anchored in the theoretical lens of the Natural Resource Based View (Hart, 1995) and ascertains the linkages between environmental policies, recycling and sustainable performance of manufacturing firms. The Natural Resource Based view is an extension of the Barney (1991) Resource Based View theoretical root that fails to include the resources related to the natural environment that facilitate the competitive advantage of firms based on the core competency and resources, which are rare and difficult to copy and replicate.

Prior studies have examined environmental laws and enforcement to ensuring firm compliance (Dasgupta, Hettige, & Wheeler, 2000), implementation of eco-design, stakeholder pressure, green supply chain management and sustainable performance (Kamalakkannan & Kulatunga, 2021; Lee, Kim & Choi, 2012 ),

recycling of waste and wealth creation and many more areas of interest at the level of individuals and households (Başaran, 2013; Kehinde et al., 2020). However, scholars have not paid attention to the relationship among national environmental policies, recycling, triple bottom line and the mediation of recycling between environmental policy and sustainable performance at the corporate level. The previous studies indicated above considered the environmental laws and enforcement for firm compliance while others assessed stakeholder pressure and sustainable performance.

The current study focuses on environmental policies and the three specific firm sustainable performance outcomes such as economic, social and environmental outcomes. Furthermore, the existing scholarship overlooked recycling practices and sustainable performance outcomes of firms as the prior studies of recycling assessed the attitude of individual citizens and households. In addition, the studies of prior scholars focus more on the individual level, assessing the attitude of individuals to disposal and recycling of household waste as against the recycling activities of manufacturing firms (Ogunseye et al.; 2024; Olufunmi et al., 2024). Besides, the studies in the past consider institutional pressures and green supply chain management and how green supply chain management affected sustainable performance.

Therefore, the link between environmental policies and recycling remains unclear and has not been adequately addressed at the firm level. In this paper, the specific research questions are a critical aspect of recycling in the greening activities of manufacturing firms. How has recycling been affected by environmental policy? And in what ways recycling has contributed to the triple bottom line of firms' economic, social and environmental performance? In what way has recycling practices mediated the nexus between environmental policy and sustainable firm performance outcomes? Therefore, the study is guided by these research questions and sets to fill the knowledge gaps identified.

The study makes consequential theoretical, empirical, practical and policy contributions to the existing literature. First, the study establishes that environmental policy in Nigeria is one of the major drivers of waste recycling of manufacturing firms. This is because for, public environmental policies have resulted in clean environment through the

compliance of corporate entities. Nonetheless, and specifically, the investigation into environmental policies and recycling of waste by corporate bodies has not been explored. In this study, how environmental regulatory pressure specifically stimulated corporate technologies leading to recycling of industrial waste is of prime focus. Second, the study also provides new important insights by examining the links between recycling and economic, social and environmental performance.

As corporate entities are deeply into global competition to attain economic performance, there are serious concerns for sustainable development from diverse stakeholders. Accordingly, corporations have begun to think and act green in the life cycle of all product development and production activities, and one of such is recycling. The question then is how does corporate recycling of waste affect the sustainable performance of firms? Third, this paper in addition, makes salient contribution to the existing body of scholarship by investigating the mediating mechanisms of recycling between environmental policies and economic, social and environmental performance. Besides, in the context of emerging economies like Nigeria, there is no existing study that addresses public environmental policy, recycling and sustainable performance of manufacturing firms in Nigeria. Thus, findings of the study are significant to African firms and economies.

The remainder of the paper is structured as follows. First, the literature is reviewed for theory and hypothesis development. The second section discusses the methodology. The third section presents results and the next segment discusses the results in line with the prior empirical evidence and the last segment examines the limitations of the study and provides direction for future studies.

## **LITERATURE REVIEW AND HYPOTHESES DEVELOPMENT**

The study draws on the theoretical paradigm of Hart (1995), who advanced the Natural Resource Based View (NRBV) of the firm. This theory underscored the need for firms to be environmentally responsible by preventing “environmental pollution, ensuring product stewardship and sustainable development”. The theoretical foundation was an extension of the Resource Based View of the firm enunciated by

Barney (1991), which does not encapsulate natural resource as one of fundamental factors or capabilities that provide the avenue for competitive edge of firms. The unique resources and capabilities at the disposal of firms enable them to engage in eco-policy frameworks, innovation, and circular economy technologies and deploy expertise to minimize industrial waste and promote environmental quality. Further, the efficient utilization of unique resources facilitates operational efficiency and investment in innovative manufacturing technologies to convert waste into useful inputs for further production and attain sustainable competitive advantage.

In the context of this study, the ability of firms to remain relevant and maintain competitive edge depends on availability of unique resources and capabilities in complying with environmental policy regimes advocated by various governments and relevant institutional frameworks. Accordingly, manufacturing firms are under obligation to maintain environmental justice by taking into account of the Extended Producer Responsibility and other extant laws of the country in the manufacture of products. This is to ensure that environmental pollution is minimized as postulated by the Natural Resource Based View (Rousseau, 2016). In keeping with product stewardship, manufacturing firms must come up with eco-designs and reverse logistic in manufacturing technology and processes all through the end of a product life cycle to minimize the emission of waste and reduce energy consumption. The focus of product stewardship becomes possible by investing in internal recycling plants, recollect and recycle waste that serve as a secondary raw material for further production. Furthermore, and in alignment with sustainable development of the NRBV, manufacturing firms must not be restricted to the market model of economic performance to the detriment of sustainable social performance and sustainable environmental performance but formulate long-term competitive and eco-strategies that facilitate the attainment of the triple bottom line and competitive advantage (Yunus & Michalisin, 2016). The main aim of sustainable development is to reduce negative impacts on the social life and physical environment arising from the activities of manufacturing firms. In consideration of the NRBV and the direction of the study, the literature is reviewed to support the hypotheses development in this paper.

### ***Environmental policy and recycling of waste materials of firms***

The attainment of sustainable development is a product of several determinants and one critical factor that accounts for corporate pursuit of sustainability goals is on account of regulatory pressures emanating from eco-friendly policy frameworks. According to Simpson (2012), institutional (both international and domestic regulatory policies) pressures and economic pressures from the lens of cost implications have led to recycling and reuse of waste. As asserted by Rondinelli and Berry (2000), that improvement in environmental quality is made manifest basically through public policy thrust from state and federal governments across countries and that such policies are enforced by governance institutions, compelling corporate bodies to comply with regulations thereby seeking different means to control pollution.

There is a high level of environmental consciousness among different stakeholders. However, the level of environmental policy regimes in Africa and Nigeria in particular has not reached the expected threshold. Albeit there is a low level of policy regimes and institutional frameworks, there are relevant environmental policies and institutions which were established to control industrial pollution in the 1980s. For instance, Federal and State Environmental Protection Agencies and the policies of national effluent limitation regulation, pollution abatement and facilities waste generating regulations in Nigeria. These policy regimes have been the driving forces for firms to respond through appropriate eco-friendly technologies and processes to ensure eco-efficiency (Adeoti, 2008). Furthermore, Extended Producer Responsibility (EPR), is one of the recent environmental policy dimensions of the National Environmental Standards Enforcement Agency [NESRA, 2007], that holds firms responsible for the different stages throughout the total life cycle of products to ensuring waste avoidance, reduction and disposal management and recycling to improve environmental quality.

In the view of Atasu and Subramanian (2012), the EPR policy framework is introduced in different parts of the world and it is intended for firms or producers to be held physically or financially responsible for the collection of the end-of-life products and recovery to prevent the discharge of harmful waste materials into the environment.

Although, from the account of Ezeudu and Ezeudu (2019), the implementation of EPR has not realized the full intended objects for its enactment. From the view of Simpson (2012), regulatory pressure no doubt accounts for recycling of waste by firms, but corporate entities may seek alternative means of dealing with waste management through third party involvement and offsite disposal options as opposed to recycling. The knowledge resource which is the internal capability and “knowhow” of employees in firms, determine the option of recycling in spite of the recycling regulatory and institutional pressures.

Recycling is one dimension of pollution control, which fosters environmental quality. The recycling of both packaging wastes and non-packaging solid wastes is a part of reverse logistics activities to ensure compliance to environmental regulation (Başaran, 2013). Recycling is the use of waste as a secondary raw material in the production of a new product, reduce various forms of environmental pollution and proffer social, economic and environmental advantage (Ayodele et al., 2018). Further, Poon et al. (2024) investigated the role of environmental policy effect on industrial and textile waste management and that stringent ecological policy reduces waste import and export in developed and developing countries. In tandem with the literature reviewed, it hypothesized that:

*H<sub>01</sub>: There is a relationship between environmental policy and recycling of waste materials of firms*

### ***Recycling of waste materials and sustainable performance of firms***

Zhang et al, (2018) and Leal Filho et al, (2019), as scholars, have acknowledged that recycling of waste materials brings about economic performance. The use of waste as secondary material in the production of new product reduces material and production cost compared to the use of primary and virgin raw materials. The reduction of production and operating cost of firms is attained through a decrease in energy consumption, service and distribution cost, and provides the groundwork for pricing and competitive advantage (Barsaran, 2013). The production efficiency creates room for enhanced profitability and economic performance of firms. Consistent with the empirical evidence of Rao and Holt (2005) that green supply chain management results in competitive advantage and economic performance, it is argued in this paper that recycling is a part of



the reverse logistic and greening activities, which provides the leeway for economic or financial performance. Economic outcomes are measured through return on investment, revenue, profit, business growth and cost efficiency (Dey et al, 2020).

In addition to the nexus between recycling and financial performance of firms, studies by implication, have also demonstrated that recycling also contributes to social performance of firms. Social performance is one of the triangular perspectives of sustainable performance from corporate vantage point and entails improving the stakeholders' quality of life through the minimization of social cost and degradation in attaining eco-efficiency (Dey et al, 2020). The social performance includes the reduction of negative impacts from industrial pollution and waste, ensuring eco-designs, recycling of waste and ultimately improves the quality of life (Yuan, 2012). In another study, Awewomom et al. (2024) asserted that environmental pollution has been a global challenge and that environmental policy agenda stimulates preventive environmental management and further reduces the environmental degradation.

The third pillar of sustainable performance is environmental performance of firms. In tandem with the position of Jimenez & Lorente (2001), environmental performance is concerned with maintaining as well as improving the quality of the natural environment while firms perform their operations function, making use of natural resources for the production of goods and services for the common good of society. It is intended to reduce negative impacts on the properties of air, water, land, and the entire ecosystem and maintain a balance in the quality of biodiversity. Accordingly, recycling is one of such environmental management innovations to ensure reduction of waste and pollutants (Jimenez et al, 2001). From the empirical evidence of Simpson (2012), institutional policy frameworks on recycling positively affected environmental performance, and domestic and international regulations and industry practice affected environmental performance of firms. Consistent with the literature reviewed, it is hypothesized that:

***H0<sub>2</sub>: There is a relationship between recycling of waste materials and economic performance of firms***

***H0<sub>3</sub>: There is a relationship between recycling of waste materials and social performance of firms***

***H0<sub>4</sub>: There is a relationship between recycling of waste materials and environmental performance of firms***

#### ***The mediation of recycling between environmental policy and sustainable performance of beverage firms***

In this section, the focus is to assess the interactions of recycling between environmental policies and sustainable performance among firms. From the existing body of available empirical literature, there appears to be no study that examine mediating role of recycling of waste materials, although there are related studies of recycling of waste, investigating it as a predictor and criterion variables. In the study of Simpon (2012), knowledge resources of employees in manufacturing firms mediated the relationship between domestic regulatory pressures, disposal cost and environmental performance.

This implies that in spite of regulatory pressure and economic benefits of recycling, it requires the internal competencies of employees for firms to actually consider the option of recycling and reuse of waste to reduce environmental degradation and injustice. Further, Chuang and Huang (2016) examined the mediation of green Information Communication Technology (ICT) capital in the relationship between environmental corporate responsibility and business competitiveness. The study demonstrated that green structural and relational capitals mediated the relationship between green corporate social responsibility and environmental performance and that of business competitiveness. This implies that innovative green activities of recycling contribute to economic and environmental performance. Green ICT capital deals with the reduction of energy consumption rate and innovative information communication technologies that reduce the emission of fumes into the air and this account for environmental performance of IT firms.

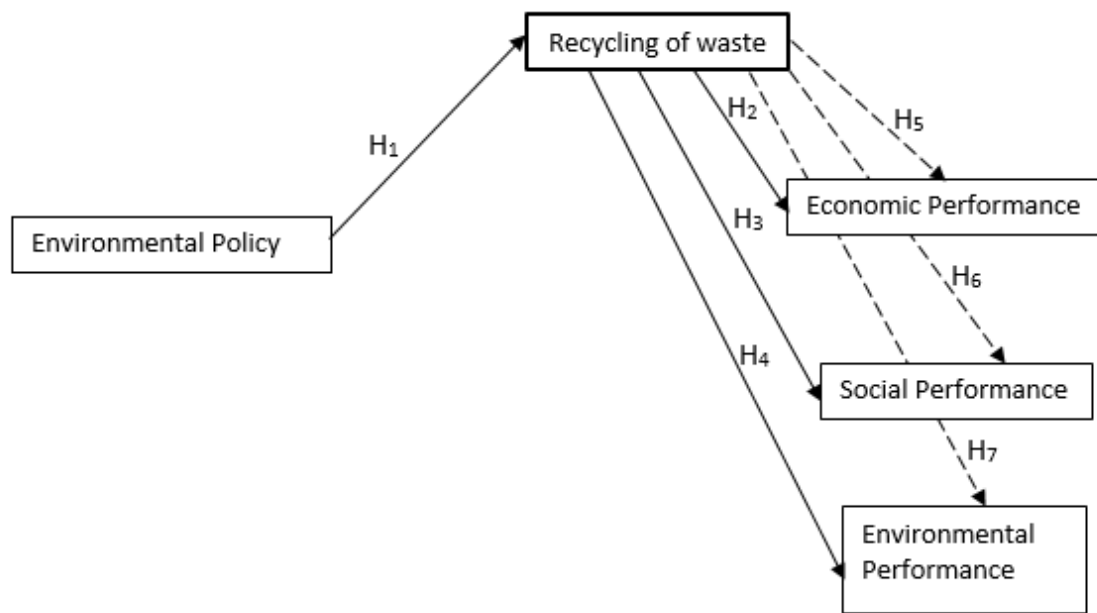
In the study of Moosa and He (2022), environmental technology is seen as a generic innovative green technologies and internal firm capability employed with the aim of reducing the consumption of energy and generation of waste through reusable and recyclable materials and

improve sustainable quality performance. Recycling is one of such innovative green technologies with the intended focus on triple bottom line. Among the findings of the scholars, environmental technology positively and significantly mediated the relationship between green operations and sustainable quality performance. In line with the literature, it is hypothesized that:

*H0<sub>5</sub>: Recycling of waste materials mediates the relationship between environmental policy and economic performance of firms*

*H0<sub>6</sub>: Recycling of waste materials mediates the relationship between environmental policy and social performance of firms*

*H0<sub>7</sub>: Recycling of waste materials mediates the relationship between environmental policy and environmental performance of firms*



KEYS ———> Direct relationship  
 -----> Indirect relationship

Fig. 1: Conceptual Framework of Environmental Policy, Recycling and Sustainable Performance of Manufacturing Firms

Source: Author's creation 2023

## METHODOLOGY

The study adopted analytical descriptive survey design method to examine the role of national environmental policy and recycling of waste for sustainable performance of manufacturing firms in Nnewi and in Port Harcourt. The study population consisted of 156 manufacturing firms that registered with the Manufacturers Association of Nigeria (MAN) in Anambra State and Rivers State. However, only 52 firms were included in the sampling frame, and these are firms that actually

engage in recycling of industrial waste in the two states. Thus, at the firm level, the target population of the study comprised 52 firms that were into recycling as ascertained by a snowballing approach through staff and managers of firms in each of the states. Furthermore, a total of 364 managers served as the accessible population as they would be adequately informed to provide reliable information about the policies, green strategies and technologies about the firms. The decision to

utilize managers was based on the study's focus on firm level of investigation in tandem with the sustainable performance as an organizational-level construct and in addition, managers have the requisite information and knowledge of the regulatory requirements, recycling programmes and the sustainability goals and performance indices of their respective firms. Accordingly, a sample of 241 managers of firms was calculated through the Yamane (1967) sample determination formula.

$$n = \frac{N}{1 + Ne^2} \text{ Where } n = \text{sample size sought, } N = \text{the population of the study, } e = \text{the error term, } 1 = \text{the theoretical constant.}$$

$$n = \frac{365}{1 + 365(0.05)^2} = 241$$

A sample of 241 managers of manufacturing firms was selected through a stratified sampling procedure and the reason for the use stratified sampling was to ensure that managers of manufacturing firms were selected on the basis of each industrial city in the two different states and various departments of manufacturing firms for the study and maintain a fair representation of various units. The questionnaires were distributed to 241 managers of manufacturing firms in Port Harcourt of Rivers State and Nnewi in Anambra State, A total of 212 pieces of questionnaire were retrieved, 29 were not returned while 38 questionnaires were discarded as they were not properly filled out by the respondents. Accordingly, a total of 174 responses from the managers were subjected to descriptive and inferential analysis.

Subjective data were collected of various managers from the administration and retrieval of structured questionnaire in Nnewi, Anambra State and Port-Harcourt, Rivers State of Nigeria. The decision to collect subjective data was due to lack of available objective data of public environmental policies, recycling, social and environmental performance in developing countries. The questionnaire included a multi-item scale of the variables (environmental policy, recycling of waste and sustainable performance) was designed on a 5-point scale of strongly agree to strongly disagree. The data were extracted from the retrieved questionnaire and the scores for the multi-item scales were averaged after initial data mining to avoid all forms of error. Accordingly, the demographic variables of the different managers were presented in a table below.

Due to issues of Common Method Variance, proactive measures recommended by (Podsakoff, MacKenzie & Podsakoff, 2003) were employed to address the challenges associated with questionnaire data collection. Therefore, the respondents were assured of anonymity to encourage honesty while responding to the survey and that the responses were not wrong or right answers. Additional measures included counterbalancing question order and improving scale items in the construction of the measurement instrument.

**Table 1: Demographic Characteristics of Sample Selected for the Study**

<i>S/N</i>	<i>Variables</i>	<i>Frequency</i>	<i>Percentage</i>
<b>A</b>	<b><i>Firm size</i></b>		
	<i>&lt;100 employees</i>	54	31.0
	<i>100-500 employees</i>	90	52.0
	<i>&gt;500 employees</i>	30	17.0
<b>B</b>	<b><i>Industry Structure</i></b>		
	<i>Food and Beverages</i>	30	17.2
	<i>Chemical and Pharmaceuticals</i>	36	20.7
	<i>Textile, Apparel &amp; Foot wear</i>	24	13.8
	<i>Pulp &amp; Paper Products</i>	24	13.8
	<i>Electricals/Electronics</i>	33	19.0
	<i>Rubber &amp; Plastic Products</i>	27	15.5
<b>C</b>	<b><i>Managers</i></b>		
	<i>Production/Operations Managers</i>	57	32.8
	<i>Quality Managers</i>	36	20.7

<i>Financial managers</i>	24	13.8
<i>Human Resource Managers</i>	24	13.8
<i>Marketing Managers</i>	33	19.0

In table 1 above, the statistics provided the frequency and percentage distribution of the demographic characteristics of the sample investigated. From the responses of the firm size, 54(31%) of the respondents were from firms of less than 100 employees, 90(52%) were from firms with the age range of 100 to 500 employees and 30(21%) were from firms of above 500 employees. This implies that the samples are well represented from manufacturing firms of different sizes for the study and would respond to the items adequately.

With respect to the industry structure, 30(17.2%) of the respondents were from food & Beverage firms, 36(20.7%) from chemical and pharmaceuticals, 24(13.8%) from textile, apparels & foot wears, 24(13.8%) from pulp & paper products, 33(19.0%) from electrical & electronics and 27(15.5%) from rubber & plastic products. The spread of the respondents from different manufacturing firms gives room for broad ideas.

For the distribution of managers, 57(32.8%) of the respondents were production/operations managers, 36(20.7%) were quality managers, 24(13.8%) were financial managers, 24(13.8%) were human resource managers, 33(19.0%) were marketing managers. The distribution of respondents who occupy managerial roles is adequate to respond to the items and the spread is across different functional managers.

### ***Measures of the Variables***

#### ***Dependent variable***

The dependent variable of the study is sustainable performance (SP) consisting of economic (EP1), social performance (SP) and environmental performance (EP2). The trinity dimensions of sustainable performance were applied in this study and the dimensions has existing scales which had been validated by prior studies. Thus, the measurement scales of Cankaya and Sezen (2018) were adapted in the current study. The economic dimension had 5 items; social dimension had 4 items while the environmental dimension had 5 items. The rationale for the measurement scales was

to ascertain the recycling and environmental policies on sustainable performance.

#### ***Independent Variable***

The independent variable in this study is public environmental policies (NEP). There were no existing scales to measure environmental policy. Therefore, the instrument was designed by the scholar through the scientific literature reviewed, which provided the relevant aspects of the policies related to green technologies (Olufunmi et al., 2024; Akinwumi et al; 2001). The instrument was designed on a 5-point Likert scale of strongly agree to strongly disagree. The measurement instrument was a multi-scale with 6 items.

#### ***Mediating Variable***

The mediating variable for the study is recycling of waste materials (RW) and there were no existing measurement scales that address recycling from the perspective of manufacturing firms. For the existing measurement scales of recycling, they were from the prism of attitude of individuals to recycling of household waste while other available scales were related to green supply chain management which cut across dimensions without adequate focus on recycling of waste. From the foregoing, measurement scales relevant to the study were designed by the researcher based on the scientific literature (Olufunmi et al., 2024; Zaman et al., 2022) and it had 5 items with response options of strongly agree to strongly disagree. The essence of the mediating variable is to ascertain the mediating role of recycling between environmental policy and sustainable performance. It is basically to reveal the direct and indirect effects of the variables.

The study applied the content validity approach by ensuring that items adequately cover all the relevant dimensions of environmental policy, recycling and sustainable performance. In terms of the reliability of the measurement instrument, Cronbach alpha was applied to determine the range of coefficients from 0.70 to 0.85. The data collected were analysed using frequency and percentage distribution to describe the demographic variables of managers in the firms. Further, the bivariate correlation and summary



statistics were applied for a preliminary analysis of the measures and variables. The fundamental analysis is the assessment of the measurement model to determine validity and reliability of the measurement indicators and the latent constructs of the study while the structural model tested the direct and indirect relationships between environmental policy, recycling and sustainable firm performance outcomes. In terms of the hypotheses postulated in the study, Partial Least Squares structural equation modeling (PLS-SEM) were utilized for the data analysis to examine the links between environmental policy, recycling and sustainable performance applying Smart PLS version 4. 2. 4 while the preliminary analysis was applied with Statistical package for Social Sciences (SPSS Version 26).

### Control Variables

The control variables of the study were firm size (FS) and industry structure (IS) which are included in the regression analysis to eliminate confounding effect in the regression models. The variables were coded in dichotomous and categorical forms. Firm size was coded as follows, <100 employees = 1; 100-500 employees = 2; > 500 employees = 3; Industry structure of the firms were pigeonholed into different categories of manufacturing firms as indicated in the samples. A prior study for example (Kholaf & Ming, 2022), applied the above variables for control at organizational level of analysis. These firm specific variables were included to control for the heterogeneity of firms and organizations to engage in sustainable performance.

## RESULTS

**Table 2: Means, Standard Deviations and Correlation Matrix of the Variables**

S/N	Variables	1	2	3	4	5	6	7
1	<i>Firm Age</i>	1						
2	<i>Industry Structure</i>	.05**	1					
3	<i>Environmental policy</i>	.69*	.75**	1				
4	<i>Recycling of Waste</i>	.19*	.15*	.52**	1			
5	<i>Economic Performance</i>	.02	.01	.17*	.03	1		
6	<i>Social Performance</i>	.05	.60*	.53**	.39**	.60**	1	
7	<i>Environmental performance</i>	.27**	.04	.35*	.49**	.15*	.49**	1
	<i>Mean</i>	-	-	3.89	3.48	3.88	3.32	4.26
	<i>Standard Deviation</i>	-	-	0.38	0.58	0.48	0.64	0.31

\*\* Significant at  $p < 0.01$ ; \* significant at  $p < 0.05$

Table 2 displays the correlation matrix with the coefficients, mean values, standard deviation values and the reliability indices of firm age, industry structure, environmental policy, recycling of waste materials, economic performance, social performance and environmental performance

### Measurement Model of Environmental Policy, Recycling and Sustainable Performance of Manufacturing Firms.

**Table 3. Convergent Validity and Reliability of Constructs of the Study.**

Variables/Latent Constructs		Cronbach alpha (CA) ≥0.70	Composite Reliability (CR) ≥0.70	Average Variances Extracted (AVE) ≥0.50	
Firm Environmental Performance					
EFP3	0.733	0.795	0.845	0.581	
EFP4	0.594				
EFP5	0.878				

<b>Environmental Policy</b>					
<b>EP1</b>	0.913	0.858	0.899	0.647	
<b>EP2</b>	0.911				
<b>EP3</b>	0.891				
<b>EP5</b>	0.641				
<b>EP6</b>	0.608				
<b>Recycling Practices</b>					
<b>RP1</b>	0.765	0.888	0.915	0.645	
<b>RP2</b>	0.794				
<b>RP3</b>	0.786				
<b>RP4</b>	0.879				
<b>RP5</b>	0.700				
<b>RP6</b>	0.878				
<b>Firm Economic Performance</b>					
<b>SEP1</b>	0.628	0.753	0.784	0.553	
<b>SEP3</b>	0.688				
<b>SEP4</b>	0.889				
<b>SEP5</b>	0.816				
<b>Firm Social Performance</b>					
<b>SFP2</b>	0.429	0.635	0.774	0.552	
<b>SFP4</b>	0.882				
<b>SFP5</b>	0.834				

Source: Output from SMART PLS, 2025.

**Table 4. Discriminant Validity of the Constructs with the Fornell-Larcker Approach**

	<b>Environmental Policy</b>	<b>Firm Economic performance</b>	<b>Firm environ performance</b>	<b>Firm social performance</b>	<b>Recycling Practices</b>
<b>Environmental Policy</b>	0.805				
<b>Firm Economic performance</b>	0.513	0.762			
<b>Firm environ performance</b>	0.560	0.479	0.744		
<b>Firm social performance</b>	0.639	0.409	0.721	0.743	
<b>Recycling Practices</b>	0.801	0.318	0.655	0.633	0.803

Source: Output from SMART-PLS 2025.

The first analysis was to assess the reliability and validity of observed variables (indicators) with a minimum threshold of 0.70 as established by Hair et al (2019). The factor loadings of several items of the measurement instrument were below the cuff-off limit and were eliminated as they do not adequately contribute to measure the latent constructs of the study. In specific terms, firm social performance with SFP1 (0.191), SFP2 (0.461), and SFP3 (0.281) while firm environmental performance with SEP3 (0.531) were deleted as the factor loadings were below the

minimum benchmark. For environmental policy, EP4 (0.031) was removed as well. After this initial analysis, a second analysis was conducted to maintain indicators with factor loadings above the minimum benchmark 0.70 and also to keep the measurement items that their removal do not enhance the Average Variance Extracted (AVE) with a minimum threshold of 0.05 as recommended by prior scholars(Hair et al, 2019; ). For example, Environmental policy with indicators of EP5 (0.641), EP6 (0.608); Firm Environmental performance with SEP1 (0.429) and Firm social

performance with indicators were maintained for the earlier reason stated.

Further, the internal consistency, reliability and convergent validity of the latent constructs were examined. The Cronbach alpha (CA), composite reliability (CR) and average variance extracted (AVE) were applied to assess the measurement constructs. For environmental policy with CA of 0.858, CR 0.899 and AVE of 0.647, there is internal consistency and reliability and convergent validity with the coefficients exceeding the minimum thresholds of 0.70 and 0.50 for reliability and convergent validity respectively. Likewise, the Cronbach alpha (CA), composite reliability (CR) and average variance extracted (AVE) for firm economic performance were 0.795, 0.838, and 0.581; for firm social performance were 0.635, 0.730, and 0.552; for firm environmental performance with 0.653, 0.809, and 0.553; for

recycling practices with 0.888, 0.892 and 0.645 showing internal consistency, reliability and convergent validity respectively with the values exceeding the cuff-marks recommended by scholars. Although, the CA values for firm environmental performance and firm social performance were just a little below the established threshold of 0.70. However, CR values were above the minimum threshold for the said constructs, confirming the internal dependability and reliability of the latent constructs. For assessing the discriminant validity of the various constructs, the Fornell-Larcker criterion (1981) was applied using the square roots of the AVE with the inter-construct correlations. The results displayed that AVE square root for each construct was higher than the correlation value of the other constructs, affirming discriminant validity of that the latent constructs are distinct measurement instruments.

**Table 5. The structural Measurement of the Environmental Policy, Recycling and Sustainable Firm Performance outcomes.**

Variables	Original sample (O) $\beta$	Standard deviation (STDEV)	T statistics ( O/STDEV )	P values	Hypotheses
<b>Environmental Policy -&gt; Recycling Practices</b>	0.801	0.028	28.903	0.000	H1
<b>Recycling Practices -&gt; Firm Economic performance</b>	-0.259	0.050	5.212	0.000	H2
<b>Recycling Practices -&gt; Firm environ performance</b>	0.576	0.072	8.057	0.000	H3
<b>Recycling Practices -&gt; Firm social performance</b>	0.340	0.059	5.786	0.000	H4
<b>Indirect Effects</b>					
<b>Environmental Policy -&gt; Recycling Practices -&gt; Firm Economic performance</b>	-0.207	0.040	5.243	0.000	H5
<b>Environmental Policy -&gt; Recycling Practices -&gt; Firm environ performance</b>	0.462	0.067	6.944	0.000	H6
<b>Environmental Policy -&gt; Recycling Practices -&gt; Firm social performance</b>	0.272	0.049	5.598	0.000	H7

Source: SMART PLS Output, 2025

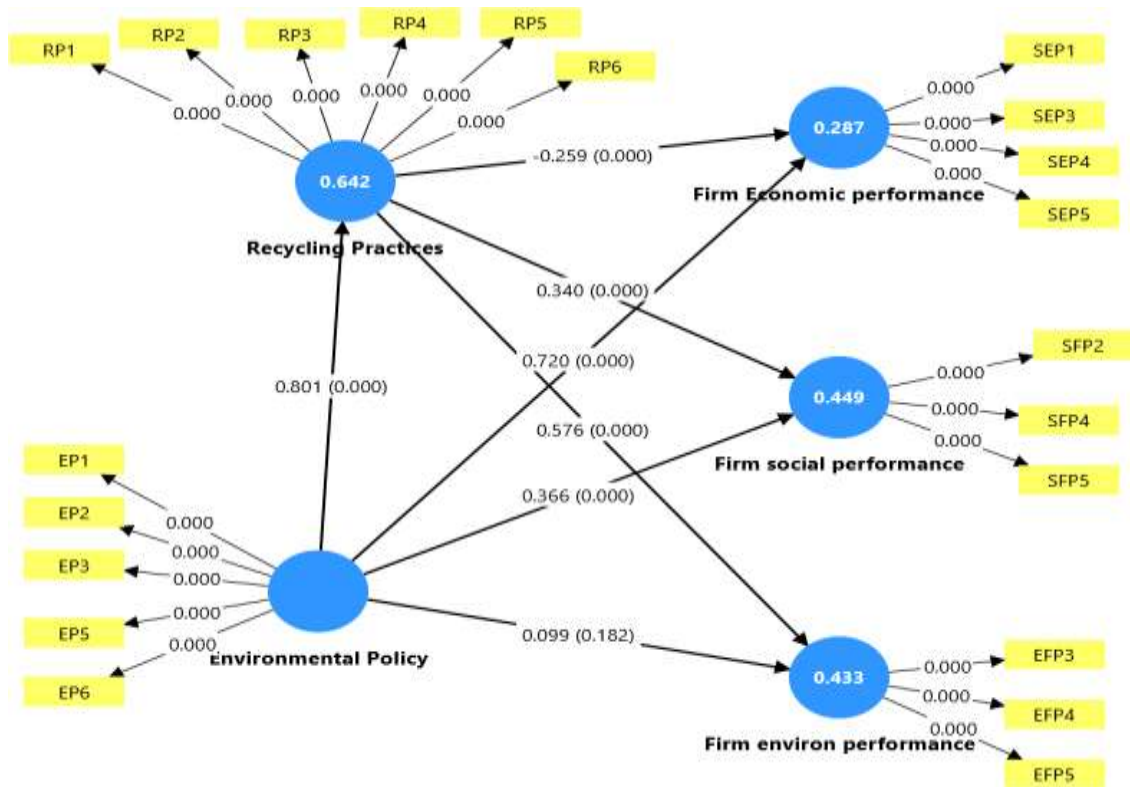


Figure 1 Structural Model of Path Diagram

The structural model was examined to determine the nexus between environmental policies, recycling and sustainable economic, social and environmental firm performance of entities. For the direct effects, the results demonstrated that environmental policy had a positive significant effect on recycling practices ( $\beta = 0.801$ ,  $t = 28.903$ ,  $p < 0.05$ ); recycling practices had a negative and significant effect on firm economic performance ( $\beta = -0.259$ ,  $t = 5.212$ ,  $p < 0.05$ ); while recycling practices had a positive and significant effect on social firm performance and environmental firm performance ( $\beta = 0.340$ ,  $t = 5.786$ ,  $p < 0.05$ ;  $\beta = 0.576$ ,  $t = 8.057$ ,  $p < 0.05$ ) respectively.

For indirect effects, the results demonstrated that the recycling practices mediated the links between environmental policy and sustainable performance outcomes. Specifically, recycling mediated the relationship between environmental policy and firm economic performance ( $\beta = -0.207$ ,  $t = 5.243$ ,  $p < 0.05$ ) firm social performance ( $\beta = 0.274$ ,  $t = 5.598$ ,  $p < 0.05$ ) and firm environmental performance. ( $\beta = 0.462$ ,  $t = 6.944$ ,  $p < 0.05$ ). In all, hypotheses H1 through H7 were supported.

## Discussion of Results

From the outcome of the data analysis, the study advanced penetrating insights into green manufacturing, production and operations management scholarship. The finding demonstrated that environmental policy influenced the recycling of waste materials in manufacturing firms in Rivers state and Anambra state. Further, one significant finding of the study is recycling of waste materials contributed to the triple bottom line of sustainable social performance and sustainable environmental performance. In addition, recycling of waste materials mediated the relationship between environmental policy and social and environmental performance.

The finding that environmental policy positively affected recycling of waste materials is consistent with the empirical evidence of Ayodele et al (2018) who found that eco-friendly policy regimes promoted greening activities of manufacturing firms in Nigeria. Consistent with the findings of Kojima, Yoshida, & Sasaki, (2009) that the environmental policy of extended producer responsibility stimulated the recycling of electronic waste, the establishment of formal electronic waste recycling enterprise and technologies. This presupposes that manufacturing plants respond to regulatory pressures by committing funds into building in-house waste recycling facilities to avoid penalties associated with violation of

environmental regulations and exploit incentives by acting in compliance with environmental policy regimes.

Further, the study also had the findings that recycling of waste materials had a negative non-significant relationship with the economic performance of firms. The findings of the current study had a negative but non-significant effect on economic performance, and this by implication demonstrated that the commitment funds into recycling technologies improves environmental and social performance of the manufacturing firms. However, the huge investments may impose economic cost on manufacturing firm thereby reducing economic returns and performance of firms. Prior findings of Cankaya and Sezen (2018) and Rao and Holt (2005) indicated that green manufacturing, green purchasing and production contributed significantly to economic performance of firms and this empirical evidence is not consistent with the current study.

The finding of the current study demonstrated that recycling of waste at the corporate level significantly contributed to social performance of manufacturing firms. This suggest that recycling reduce problems that confronted stakeholders emanating from the manufacture of goods. The current empirical evidence lends credence to the prior study of Cankaya and Sezen (2018) that green supply chain management activities were related to social performance of firms. To further buttress the empirical evidence of the current study, Muller and Kolk (2010) also stated that management commitment as an intrinsic driver, an explanation of ethical behaviour as against a regulatory requirement, to greening activities of firms accounted for corporate social performance,

The present study found that recycling of waste had significant positive effect on corporate environmental performance. The finding of the study was underpinned by Simpson's (2012) investigation of recycling pressure and environmental performance mediated by knowledge resources. The findings from the study indicated that recycling regulations prompted corporate entities to engage in collection and reuse of waste materials leading to environmental performance. Although the prior investigation focuses on the mediation of knowledge resources and regulatory pressure with particular emphasis on recycling, the findings are still related to some extent as an indirect nexus between recycling regulatory pressure and corporate environmental

performance. The empirical evidences of the current study, in addition, underpinned the NRBV theoretical paradigm of Hart (1995) which underscored pollution prevention, product stewardship and sustainable development among corporate entities. In view of the study, compliance with environmental policy regimes to ensure "pollution prevention", recycling of waste as a means to achieve "product stewardship" leading to sustainable economic, social and environmental performance of manufacturing firms.

### **MANAGERIAL AND POLICY IMPLICATIONS**

The findings of the study proffer practical and managerial implications. Managers of manufacturing firms should be conversant with environmental and recycling policy frameworks to increase sustainable economic, social and environmental performance. This presupposes different managers at different levels are to allocate resources and direct firms to invest in recycling system to collect, treat, and reuse waste materials to reduce economic, social and environmental costs associated with injustice and degradation. The investments in recycling programs should be holistic by involving training of personnel and technologies for effective and efficient waste management. The results indicated that national eco-friendly policies impacted recycling of waste materials in manufacturing firms. The result implies that managers of manufacturing firms need to in tune with policy dynamics and align green strategies with national green policy thrusts to leverage on support programmes of governments. Further, manufacturing entities should give preference for recycling initiatives with a view to boosting corporate reputation before the diverse stakeholders in Nigeria. Although recycling had no significant effect on sustainable economic performance in manufacturing firms, managers should locate and deal with obstacles to economic potentials recycling and recycling processes to have optimum economic advantages.

The policy implication is for relevant agencies of government like NESRA and National Agency for Food and Administration Control (NADAC) to build robust monitoring system and enforce pollution abatement regulations and ensure that the extended producer responsibility (EPR) policy



framework is fully implemented in Nigeria. Pro-environmental institutions of government should come up with policy incentives of tax holiday, recycling infrastructure and technologies to encourage firms to engage recycling and management of industrial waste at the firm level. Further, policy makers should earmark funds for research and development and develop green innovative technologies to improve environmental quality.

### LIMITATIONS AND DIRECTION FOR FUTURE STUDIES

The study offered important contribution to management scholarship but there are limitations. Accordingly, there would be need for future research direction. The study was conducted in two industrial cities in the South-South and South East, Nigeria. This limitation in geographical scope

suggests that the findings may not adequately represent other regions in Nigeria. In this regards, caution is required when attempting to generalize the findings across the entire country. Consequently, caution is required to make generalization across Nigeria. Thus, further studies should cover more cities in Nigeria.

With respect to the limitations of methodology, a cross sectional design was employed in the study, where data were collected at a single point in time. This design is effective for capturing a snapshot of the variables of interest but for the inability of cross-sectional studies to establish causality. In line with these limitations, future studies should include several industrial cities in different regions in Nigeria to enhance the generalizability of research findings. Thus, longitudinal design is recommended to ensure that data is collected in waves for future studies as a better option to determine causation of the variables investigated.

### REFERENCES

- Adekunle, S. A., & Dakare, O. (2020). Sustainable manufacturing practices and performance of the Nigerian table water industry: a structural equation modeling approach. *Management of Environmental Quality: An International Journal*, 31(4), 1003-1022.
- Adeoti, J. O. (2008). Environmental policy and industrial response in Nigeria. *International Journal of Technology Management & Sustainable Development*, 7(2), 119-136
- Akinwumi, I. O., Oyebisi, T. O., & Salami, A. T. (2001). Environmental degradation in Nigeria: implications and policy issues—a viewpoint. *International Journal of Environmental Studies*, 58(5), 585-595.
- Akuma, J. K., Tackie, G., Idun, A. A. A., & Kwaning, E. A. (2024). Management Accounting Practices and Sustainability Performance of Manufacturing Firms in Ghana. *American Journal of Industrial and Business Management*, 14(2), 214-241.
- Atasu, A., & Subramanian, R. (2012). Extended producer responsibility for e-waste: Individual or collective producer responsibility. *Production and Operations Management*, 21(6), 1042-1059.
- Awewomom, J., Dzeble, F., Takyi, Y. D., Ashie, W. B., Ettey, E. N. Y. O., Afua, P. E., ... & Akoto, O. (2024). Addressing global environmental pollution using environmental control techniques: a focus on environmental policy and preventive environmental management. *Discover Environment*, 2(1), 8.
- Ayodele, T. R., Alao, M. A., & Ogunjuyigbe, A. S. O. (2018). Recyclable resources from municipal solid waste: Assessment of its energy, economic and environmental benefits in Nigeria. *Resources, conservation and recycling*, 134, 165-173.
- Barney, J. (1991). Firm resources and sustained competitive advantage. *Journal of management*, 17(1), 99-120.
- Başaran, B. (2013) What makes manufacturing companies more desirous of recycling? *Management of Environmental Quality*, 24(1), 107-122. <https://doi.org/10.1108/14777831311291177>
- Cankaya, S. Y., & Sezen, B. (2018). Effects of green supply chain management practices on sustainability performance. *Journal of Manufacturing Technology Management*.30(1), 98-121.

<https://doi.org/10.1108/JMTM-03-2018-0099>

- Chardine-Baumann, E., & Botta-Genoulaz, V. (2014). A framework for sustainable performance assessment of supply chain management practices. *Computers & Industrial Engineering*, 76, 138-147.
- Chokor, B. A. (1993). Government policy and environmental protection in the developing world: The example of Nigeria. *Environmental Management*, 17(1), 15-30. <https://doi.org/10.1007/BF02393791>
- Chuang, S. P., & Huang, S. J. (2018). The effect of environmental corporate social responsibility on environmental performance and business competitiveness: The mediation of green information technology capital. *Journal of business ethics*, 150(4), 991-1009
- Dasgupta, S., Hettige, H., & Wheeler, D. (2000). What improves environmental compliance? Evidence from Mexican industry. *Journal of Environmental Economics and Management*, 39(1), 39-66.
- de Burgos Jimenez, J., & Lorente, J. J. C. (2001). Environmental performance as an operations objective. *International Journal of Operations & Production Management* 21,(12)1553-1572. <https://doi.org/10.1108/01443570110410900>
- Ebekozien, A., Aigbavboa, C., Emuchay, F. E., Aigbedion, M., Ogbaini, I. F., & Awo-Osagie, A. I. (2022). Urban solid waste challenges and opportunities to promote sustainable developing cities through the fourth industrial revolution technologies. *International Journal of Building Pathology and Adaptation*, (ahead-of-print). <https://doi.org/10.1108/IJBPA-09-2021-0119>
- Ezeudu, O. B., & Ezeudu, T. S. (2019). Implementation of circular economy principles in industrial solid waste management: Case studies from a developing economy (Nigeria). *Recycling*, 4(4), 42.
- Ezeudu, O. B., & Ugochukwu, U. C. (2024). Financing mechanism for solid waste management in Anambra, Nigeria: analyses of emerging challenges and implication for circular economy. *Environmental Science and Pollution Research*, 1-19.
- Fornell, C., & Larcker, D. F. (1981). Structural equation models with unobservable variables and measurement error: Algebra and statistics. *Journal of Marketing Research*, 18: 13-50
- Hart, S. L. (1995). A natural-resource-based view of the firm. *Academy of Management Review*, 20(4), 986-1014.
- Kalu, U., & Origbakpor, C. E. (2024). Understanding the roles of NESREA in the management of medical waste in Nigeria: challenges and prospects. *African Journal of Law and Human Rights*, 7(2). 124-128
- Kamalakkannan, S., & Kulatunga, A. K. (2021). Optimization of eco-design decisions using a parametric life cycle assessment. *Sustainable Production and Consumption*, 27, 1297-1316.
- Kehinde, O., Ramonu, O. J., Babaremu, K. O., & Justin, L. D. (2020). Plastic wastes: environmental hazard and instrument for wealth creation in Nigeria. *Heliyon*, 6(10), e05131.
- Kholaif, M. M. N. H. K., & Ming, X. (2022). COVID-19's fear-uncertainty effect on green supply chain management and sustainability performances: the moderate effect of corporate social responsibility. *Environmental Science and Pollution Research*, 1-22.
- Kojima, M., Yoshida, A., & Sasaki, S. (2009). Difficulties in applying extended producer responsibility policies in developing countries: case studies in e-waste recycling in China and Thailand. *Journal of Material Cycles and Waste Management*, 11(3), 263-269.
- Lawal, A. M., Igbekoyi, O. E., & Dagunduro, M. E. (2024). Sustainability reporting and value creation in selected listed manufacturing companies in Nigeria. *International Journal of Accounting, Finance and Social Science Research*, 2(1), 39-56.

- Leal Filho, W., Ellams, D., Han, S., Tyler, D., Boiten, V. J., Paço, A., ... & Balogun, A. L. (2019). A review of the socio-economic advantages of textile recycling. *Journal of cleaner production*, 218, 10-20.
- Lee, S. M., Kim, S. T., & Choi, D. (2012). Green supply chain management and organizational performance. *Industrial Management & Data Systems*.
- [Li, C.](#), [Liu, F.](#) and [Wang, Q.](#) (2010), "Planning and implementing the green manufacturing strategy: evidences from western China", *Journal of Science and Technology Policy in China*, Vol. 1 No. 2, pp. 148-162. <https://doi.org/10.1108/17585521011059884>
- Moosa, A., & He, F. (2022). The relationship between green operation and sustainable quality performance: the mediation role of environmental technology. *Journal of Environmental Planning and Management*, 65(8), 1414-1435.
- Muller, A., & Kolk, A. (2010). Extrinsic and intrinsic drivers of corporate social performance: Evidence from foreign and domestic firms in Mexico. *Journal of Management studies*, 47(1), 1-26.
- Mwanza, B. G., Mbohwa, C., & Telukdarie, A. (2018). Strategies for the recovery and recycling of plastic solid waste (PSW): A Focus on Plastic Manufacturing Companies. *Procedia Manufacturing*, 21, 686-693. <https://doi.org/10.1016/j.promfg.2018.0>
- Niesten, E., Jolink, A., de Sousa Jabbour, A. B. L., Chappin, M., & Lozano, R. (2017). Sustainable collaboration: The impact of governance and institutions on sustainable performance. *Journal of cleaner production*, 155, 1-6
- Njoku, D. I., & Nwodeh, P. (2024). Re-thinking waste management regime for effective environmental protection in Nigeria. *African Journal of Law and Human Rights*, 7(2), 153-160
- Ogbeibu, S., Emelifeonwu, J., Pereira, V., Oseghale, R., Gaskin, J., Sivarajah, U., & Gunasekaran, A. (2024). Demystifying the roles of organisational smart technology, artificial intelligence, robotics and algorithms capability: A strategy for green human resource management and environmental sustainability. *Business Strategy and the Environment*, 33(2), 369-388.
- Ogunseye, N. O., Ogunseye, O. D., Ogunseye, A. O., Tongo, S. O., Oladesu, J. O., Oyinloye, M. A., & Uzzi, F. O. (2024). Leveraging Waste Recycling as a Gateway to a Green Economy in Nigeria. *The Journal of Indonesia Sustainable Development Planning*, 5(1), 27-37.
- Ojala, M. (2007). Confronting macrosocial worries: Worry about environmental problems and proactive coping among a group of young volunteers. *Futures*, 39(6), 729-745.
- Olatayo, K. I., Mativenga, P. T., & Marnewick, A. L. (2022). Does policy on plastic waste support higher waste management hierarchy options?. *Recycling*, 7(3), 36 1-23
- Olufunmi, T., Modupe, A., & Olumide, O. O. (2024). Poverty Reduction Measurement: A Community Based Recycling Program to Reduce Waste and Promote Sustainable Living. *Educational Perspectives*, 12(3). 1-23
- Podsakoff, P. M., MacKenzie, S. B., Lee, J. Y., & Podsakoff, N. P. (2003). Common method biases in behavioral research: a critical review of the literature and recommended remedies. *Journal of applied psychology*, 88(5), 879-903
- Poon, J. P., Peng, P., & Atkinson, J. D. (2024). Industrial and textile waste trade: Multilayer network and environmental policy effects. *Waste Management*, 177, 146-157.
- Rao, P. & Holt, D. (2005), "Do green supply chains lead to competitiveness and economic performance?", *International Journal of Operations & Production Management*, 25 (9), 898-916. <https://doi.org/10.1108/01443570510613956>
- Relph, E. (2016). Senses of place and emerging social and environmental challenges. In *Sense of place, health and quality of life* (pp. 51-64).

- Rondinelli, D. A., & Berry, M. A. (2000). Corporate environmental management and public policy: Bridging the gap. *American Behavioral Scientist*, 44(2), 168-187.
- Rousseau, H. E. (2017). Corporate sustainability: Toward a theoretical integration of catholic social teaching and the natural-resource-based view of the firm. *Journal of Business Ethics*, 145(4), 725-737.
- Sasmoko, S ; Zaman, K.; Malik,M.; Awan, U.; Handayani,W.; Jabor,M.K.; Asif, M. (2022).Environmental effects of bio-waste recycling on industrial circular economy and eco-sustainability .*Recycling* 7(4); 1-21, <https://doi.org/10.3390/recycling7040060>
- Simpson, D. (2012). Knowledge resources as a mediator of the relationship between recycling pressures and environmental performance. *Journal of Cleaner Production*, 22(1), 32-41.
- United Nations (2023) Sustainable Development Report [SDR], Sustainable Development Solutions Network
- Yamane, T. (1967), *Statistics: An Introductory Analysis*, Harper & Row.
- Yunus, E. N., & Michalisin, M. D. (2016). Sustained competitive advantage through green supply chain management practices: a natural-resource-based view approach. *International Journal of Services and Operations Management*, 25(2), 135-154.
- Zaman, K., Malik, M., Awan, U., Handayani, W., Jabor, M. K., & Asif, M. (2022). Environmental effects of bio-waste recycling on industrial circular economy and eco-sustainability. *Recycling*, 7(4), 60. 1-20
- Zhang, B., Lai, K. H., Wang, B., & Wang, Z. (2018). Financial benefits from corporate announced practice of industrial waste recycling: Empirical evidence from chemical industry in China *Resources, Conservation and Recycling*, 139, 40-47.