LINKING ECO-INNOVATION TO LONG-TERM SUSTAINABILITY OF PACKAGING FIRMS IN KOGI STATE, NIGERIA

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ABSTRACT

Package manufacturing firms in Kogi state Nigeria, face growing pressure to adopt sustainable practices due to rising environmental concerns and regulatory demands. However, there is limited empirical evidence on how adoption of eco-innovation strategies affected the sustainable packaging practices. This study examined the effect of eco-innovation strategies on the sustainability of these firms, using dynamic capability theory as the theoretical framework. A cross-sectional survey design with a quantitative approach was employed. Data were collected from 174 top managers across 31 firms using a structured Likert-scale questionnaire. The study adopted a census method due to the relatively small population. Data analysis involved descriptive statistics and fixed-effect regression to evaluate the effect of eco-innovation strategies specifically proxied by collaboration strategy, eco-engineering, green knowledge sharing and environmental regulation on economic sustainability. The regression results established that eco-innovation strategies accounted for 64% of the variation in sustainability outcomes ($R^2 = 0.64$). Collaboration strategy ($\beta = 0.184$, $P = 0.000$), eco-engineering ($\beta = 0.076$, $P = 0.022$) and green knowledge sharing ($\beta = 0.068$, $P = 0.033$) had significant positive effects on firms sustainability. However, environmental regulation ($\beta = 0.002$, $P = 0.096$) was not statistically significant. The study concludes that eco-innovation strategies significantly enhance the sustainability of package manufacturing firms and recommends their integration into operational practices to promote long-term environmental and economic performance.

Keywords: Green knowledge, Eco-products, Eco-marketing, sustainability

1.1 Background to the Study

The global industrial landscape is undergoing a paradigm shift as environmental concerns, climate change, and resource scarcity increasingly dictate the terms of business operations. Eco-innovation defined as the development and application of products, processes and organizational methods that reduce environmental harm, is fast becoming a strategic imperative for firms seeking long-term sustainability (OECD, 2009). In the context of manufacturing, especially in the packaging sector, eco-innovation serves as a vital mechanism for reducing carbon footprints, improving resource efficiency and meeting environmental compliance standards.

Nigeria, like many developing countries, faces a dual challenge: the need to stimulate industrial growth and innovation while minimizing environmental degradation. The packaging industry, which plays a crucial role in food security, pharmaceuticals and consumer goods distribution, generates significant environmental impacts due to its reliance on plastic, energy-intensive processes and unsustainable disposal practices. In Kogi State, the expansion of packaging firms has created both economic opportunities and environmental challenges. The need to balance industrial growth with ecological sustainability underscores the urgency of embedding eco-innovation practices in this sector.

Despite the rising importance of sustainability, many Nigerian packaging firms operate with limited integration of eco-innovation strategies. This may be attributed to institutional voids, low environmental

awareness, poor regulatory enforcement and weak inter-firm collaboration. However, eco-innovation when strategically driven by elements such as collaborative networks, eco-engineering capabilities, green knowledge sharing and effective environmental regulations has the potential to enhance firms' long-term competitiveness and ecological resilience.

Collaboration among stakeholders (e.g., suppliers, government, research institutions) fosters knowledge exchange and resource pooling, thereby enabling innovation at scale. Eco-engineering, which emphasizes environmentally conscious design and production, helps firms reduce waste and optimize energy use. Green knowledge sharing further facilitates organizational learning and innovation diffusion. Environmental regulation, though often seen as a constraint, can also act as a stimulus for innovation by compelling firms to adopt cleaner technologies and sustainable practices.

Previous studies have explored eco-innovation in various sectors but empirical evidence linking its multidimensional constructs to the long-term sustainability of packaging firms, particularly in subnational contexts like Kogi State, remains limited. Moreover, most extant literature is skewed towards developed economies, leaving a gap in understanding how eco-innovation functions in low-resource settings with institutional and infrastructural constraints.

This study therefore seeks to bridge this gap by empirically examining the extent to which eco-innovation measured through collaboration, eco-engineering, green knowledge sharing, and environmental regulation contributes to the long-term sustainability of packaging firms in Kogi State, Nigeria. By adopting the dynamic capability theory as its theoretical lens, the study aims to provide insights into how firms can develop adaptive and transformative capacities to thrive in an increasingly sustainability-oriented business environment.

1.2 Aim and objectives of the study

The primary objective of this study is to investigate the effect of eco-innovation strategies on the long-term sustainability of plastic manufacturing firms in Kogi State. In pursuit of this overarching goal, the study articulates the following specific objectives:

i. To assess the influence of collaborative eco-innovation strategies on the sustainability performance of plastic manufacturing firms.
ii. To evaluate the effect of eco-engineering practices on the sustainable development of plastic manufacturing firms.
iii. To determine the extent to which green knowledge sharing contributes to the sustainability outcomes of plastic manufacturing firms.
iv. To examine the role of environmental regulatory frameworks in shaping the sustainability trajectory of plastic manufacturing firms.

2.1 The concept of eco-innovation

Eco-innovation has been viewed and defined variably by scholars. For instance, Pakulska and Rutkowska (2019) described the term eco-innovation as a new concept derived from the prefix 'eco' comes from the word 'ecology', whereas 'innovation' means everything that is new. development of a new product that considerably lessens the adverse effects on the environment while adding value for the customer and business. Furthermore, it is interesting to note that the idea of eco-innovation arises when corporate operations align with environmental standards.

More so, the concept of eco-innovation was first developed by Fussler and James in 1996 and defined as the reduction of negative environmental impacts while providing new products and processes as a benefit to the customer and the business (Hojnik and Ruzzier, 2016). Interestingly, the concept of eco-innovation emerges when business practices are harmonized with environmental expectations. Yurdakul and Kazan (2020) also defined eco-innovation as new ideas, behaviour, products and processes that

contribute to a decreased environmental burden. Eco-innovation contributes to environmental responsibility and sustainability goals through the realization of new ideas, behaviour, products and processes. Arranz et al. (2020) comprehended eco-innovation to be the innovation that seeks to reduce pollution and contribute to a sustainable economy, while improving economic performance.

Literatures such as (Araujo and Franco, 2021; Yun and Xiaofei, 2020) established the existence of several terms to designate eco-innovation such as green innovation, ecological innovation and environmental innovation which are generally used to describe all those innovations that reduce negative impacts on the environment and that improve sustainability. In a broader sense, Saez-Martínez et al., (2019) defined eco-innovation as all measures of relevant involved persons who develop new ideas, behaviours, products and processes and then apply or introduce them and who contribute to a reduction in environmental burdens or to ecologically specified sustainability targets. Eco-innovation thus encompasses elements such as innovation in technologies for energy saving and pollution prevention, waste recycling, design of new ecological products, and corporate environmental management (Chen et al., 2006). Therefore, the manufacturing sector need to constantly innovate their business processes, as customer needs are constantly changing according to current trends to move toward societal and environmental efficiency through eco-innovation. Significantly, eco-innovation can serve as a tool for companies with the intention to transform environmental constraints into opportunities to reduce costs obtain.

2.2 Dimensions of eco-innovation

Eco-innovation activity is a complex phenomenon that comprises a series of innovations which can be classified into four dimensions: product, process, organization and marketing (Garcia-Granero et al., 2018). The four dimensions of Eco-innovation exist together in all sectors; so, developing a scale to measure them by identifying their key performance factors is crucial to achieving an accurate measurement level of Eco-innovation implementation as discussed under the following subheadings:

2.2.1 Eco-product innovation

Eco-product innovation refers to the introduction of environmentally-friendly new products or significant improvements of product characteristics, such as advances in technical components and materials (Garcia-Granero et al., 2020). According to Yurdakul and Kazan, (2020) highlighted eco-product innovation as the reduction of environmental impacts through the significant improvement of new or existing products or services. This innovation aims to reduce environmental impacts (Cheng et al., 2014), improve environmental performance, meet the market's environmental expectations, and increase resource efficiency whilst achieving optimal environmental benefits in the whole product life cycle (Dong et al., 2014). Eco-product innovation is a gateway to new and essentially improved products, in line with technological and environmental innovation (Arfi et al., 2018). Innovation practices can be achieved by adapting efficient eco-product innovation within the business firm (Maldonado-Guzman and Garza-Reyes 2020). The manufacturing sector needs to produce a high-quality output that is less harmful to the environment and safe to be used by consumers. According to Yao et al. (2019), companies engaging in eco-product innovation may regard it as an opportunity and potential source of income for their company.

2.2.2 Eco-process innovation

Eco-process innovation refers to change in business processes and systems (Yurdakul and Kazan, 2020), which increases productivity, reduces greenhouse gas emissions, and reduces resource costs. Eco-process innovation can be seen as an attempt to incorporate the eco-innovation initiatives into the manufacturing processes (Dahan and Yusof, 2019). This includes the introduction of new production processes, technologies or methods, or the improvement of current processes so as to prevent and

minimize the negative environmental impacts (Cheng et al.,2014). Dahan and Yusof, (2019) refers to eco-process innovation as 'any eco-innovation activities performed on production processes which aimed at or resulted in the reduction of unfavourable environmental impacts. Additionally, it replaces harmful inputs, optimizes the production process, and reduces the negative effects of production output. Clean production, zero emissions, zero waste, and material efficiency are realized within the scope of this kind of innovation.

2.2.3 Eco-organisational innovation

Another dimension of eco-innovation, namely, eco-organizational innovation, is also known as eco-management innovation. This eco-innovation highlights the goal of a new firm in the market via access to difficult-to-replicate knowledge, which is critical for the environment with insufficient legal protections. According to Zulkiffli et al. (2022), eco-management refers to new initiatives and procedures assigned to organisational systems. It can boost productivity and lower administrative costs while sustaining business performance. It also determines the types of ideas of eco-techniques that should be used during the product manufacturing process so that the waste from the manufacturing of eco-products does not harm the environment. In addition, management innovations entail the implementation of new business practices that encompass new organizational procedures and routines (Ozturk and Ozen, 2021), including, for example, knowledge, supply chains, and quality management. Additionally, eco-organisational innovation refers to various ideas from owners and managers in developing any business strategies for the firm, such as product, process, marketing, or technology innovation, and others that may guide manufacturing firms to meet value and advantages for the internal and external environment (Hervas-Oliver et al., 2021). Thus, employees who are exposed to eco-management in the form of new knowledge may be more efficient during the manufacturing process.

2.2.4 Eco-marketing innovation

Eco-marketing innovation involved all dimensions of product design or packaging, product placement, product promotion, and prices. Eco-marketing refers to the decision making in changes to pricing strategy, product design, branding, promotion, and packaging that increases the value offered to fulfil the customer's demand (Islami et al., 2020; Varadarajan, 2018). According to (Garcia-Granero et al., 2018), the techniques that lead people to buy eco-innovative products are the main subject of eco-marketing innovation. The buying decision of customers is not only affected by cost, quality, and delivery, but also by the firm's green image and sustainability. Sukri et al. (2023) reported that marketing plays an important role in changing consumer behaviours towards ecological products, raising consumers' awareness of resource-saving products and transferring the benefits of products with reduced environmental impact to consumers. With eco-marketing, consumer-buying behaviour is affected in the desired direction and the product can hold on to the market. Therefore, eco-marketing innovation plays an important role in the success of eco-innovation applications. The effects of eco-marketing innovation can also increase the manufacturing industry's competitive advantage (Ho et al., 2021).

2.3.1 Eco-innovation strategy

Janahi et al., (2021) defined eco-innovation strategy as a set of actions and commitments by manufacturing firms for realizing innovation that targets and boosts sustainable development. Also, Tamayo-Orbegozo et al. (2017) defined eco-innovation strategy as the capabilities of a firm to build an environment that supports innovation and enables it to distinguish itself from competitors on the basis of the unique products or services that can be offer to clients and end-users.

Eco-innovation strategy requires the firms to embrace changes and adapt to a dynamic environment, thus contributing to a competitive advantage (Salim et al., 2019). Manufacturing firm able to use its

capabilities and resources in different combinations to create eco-innovation strategies, from which it can develop and apply this innovation to achieve its goals and enhance its environmental performance. As changes in the environment represents the changes in competition, regulation, market pressure and other stakeholder demands. Therefore, understanding the strategies to eco-innovate is critical.

Therefore, the challenge for manufacturing firms remains to analyse eco-innovation strategies for an inclusive view of environmental, green, and sustainability-oriented solutions. From the review of the literature, it is strongly agreed that innovation is the main sources of competitive advantages, and this can be achieved with proper strategies. As supported by (Isa et al., 2019), a firm obtains competitive advantages when it implements a value-creating strategy. The benefits of eco-innovation are not limited to improve environmental performance, but it also enables firms to attain numerous monetary and economic advantages (Juniati et al., 2019). Eco-innovation helps manufacturing firms insert environmental issues into their business strategy in order to create or consolidate their sustainability and competitive advantages. Indeed, it has been demonstrated by (Cheng et al., 2014; Dong et al., 2014) that the performances of Eco-innovation are positively correlated to firm sustainability (competitive advantage).

2.3.1.1 Collaborative Strategy

Collaboration refers to the activities carried out by firms with other companies and organizations for the use and exchange of information to creation of products, development of ideas, exchange of data, and development of plans jointly and improvement of production processes (Garces-Ayerbe et al., 2019). The lack of resources and the limited existing knowledge within the manufacturing companies of the plastic, leather and rubber manufacturing industry, necessary for the development of processes eco-innovation, can be compensated through collaboration with suppliers, clients, centres of research and government agencies (Kobarg et al., 2020), which can not only share their resources and knowledge, but also the technology for the development of eco-innovation of production processes (Tumelero et al., 2019).

2.3.1.2 Eco-engineering

Eco-engineering, also known as sustainable engineering or green engineering refers to the application of engineering principles and practices to design, develop, and improve manufacturing processes, products, and systems in an environmentally friendly and sustainable manner (Babu et al., 2023). It involves integrating environmentally conscious considerations into every stage of the manufacturing life cycle, from raw material acquisition to product disposal. The importance of eco-engineering in manufacturing cannot be overstated, given the growing concerns about climate change, resource depletion, and environmental degradation (Gaspar et al., 2017). According to Borisov et al., (2019) reported that Odum in 1962 was among the first to use the term ‘ecological engineering’, which was viewed as ‘environmental manipulation by man using small amounts of supplementary energy to control systems in which the main energy drives are still coming from natural sources. Interestingly, eco-engineering has a crucial role in defining and achieving the sustainability target of plastic manufacturing concern. Better eco-engineering practices would help better in reducing the adverse impacts on the environment and society, but also on the financial performance of firms. Eco-engineering, defined as the proactive design of sustainable ecosystems which integrate human society with its natural environment for the benefit of both (Mickovski, et al., 2022) is usually used broadly to describe long-term, ecological strategies to manage land with regard to natural or man-made hazards. The integration of manufacturing techniques with natural or man-made materials to obtain fast, effective, and economic methods of protecting, restoring, and maintaining the environment and nature-based solutions (European Commission, 2021).

2.3.1.3 Green knowledge sharing

Green knowledge management (GKM) is a novel concept of knowledge management aiming to integrate green or environmental aspects into all dimensions of knowledge management. In the current globalized market, as recommended by the United Nations, eco-friendly practices and information extend beyond the single organization to all stakeholders (United Nation Development Programme, 2021). During the preceding few years, the debate about environmental issues has gained much attention. Credit goes to ecologists for their continuous efforts to create awareness about dwindling natural resources and the damage caused to the natural environment because of the rapid consumption of resources by businesses worldwide (Kumar and Barua, 2022). Song et al. (2020) reported from the publication of the United Nations' Brundtland Commission, 1987 businesses have started shifting their focus on sustainable development. They are trying to integrate the knowledge pertaining to nature and society into new concepts and theories. Green knowledge is not solely about information relating to a natural condition; it has a broad spectrum of how we should react to that situation and consider following a more sustainable environmental, social, and economic development path. Wang et al. (2020) stated that green knowledge is essential for individual and organizational green creative performance. Moreover, individuals' green learning orientation leads to firms' new eco-knowledge, which ultimately results in new ideas, thoughts, and solutions, leading to new products, technology, and services. If a firm wants maximum benefits from GKM, it must execute it as a system by involving all stakeholders so that decisions can be made on what to discard, continue, and improved upon.

2.3.1.4 Environmental regulations and protection strategy

Environmental regulations represent organisational, institutional, and regional strategies and policies for engaging in eco-innovation, and such regulations are mostly relevant to late comers who become obliged to adopt and adhere to minimum standards for environmental protection (Janahi et al, 2021). Studies such as (He et al., 2019; Li and Liu, 2018 and Jin et al., 2017) noted environmental regulations and protection significantly relates to eco-innovation capability and progress (Liu and Gong, 2018; Dangelico et al., 2017), and the output of innovation activity (Yi et al., 2020). Thus, environmental regulations remain the most influential enablers for eco-innovation (Gupta and Barua, 2018) and for conducive settings that improve eco-innovation efficiency (Feng and Chen, 2018). However, research notes that environmental regulations tend to have two effects on technologies for eco-innovation: innovation offset and compliance cost (Liu and Gong, 2018). Studies also indicate different influences of different regulations. For instance, a study finds that command type environmental regulations significantly relate to eco-innovation, while incentive-type environmental regulations have insignificant effects on eco-innovation (Jin et al., 2017). Policies, which inform decisions, also offer avenues for inducing manufacturing eco-innovation. Examples include fiscal policies, such as low cost (subsidised) finance for innovation and fiscal incentives for sustainable practices (Gramkow and Anger-Kraavi, 2018 and Liao and Tsai, 2019). There are also recycling policies complementary to the carbon emission constraint mechanism in a hybrid manufacturing system (Zhang et al., 2019), and liberalisation policies in R&D sectors to boost technology development.

2.4 Concept of sustainability

The first definition for sustainability was captured in the United Nations (UN) Brundtland Commission report published in 1987: "Development which meets the needs of current generation without compromising the ability of future generations to meet their own needs" (International Trade Administration, 2012). According to Adeyeye et al., (2018) sustainability is perceived in three dimensions: social, economic and environmental, though not limited to these. The concept of sustainability is a concept of development directed towards achieving a balance between social aspects,

economic activities, and the environment (Derlukiewicz et al., 2020). The term sustainability is widely discussed in present political and environmental discourses (Pravitasari et al., 2018).

At the manufacturing level, sustainability has assumed a fundamental role over the years, and can be defined as developing manufacturing practices which can be scaled or right-sized without unreasonable exhaustion of resources, or to the exclusion of some populations. Sustainability consists of a wide scale of models connected to integrating economic, social, and ecological concerns (Purvis et al., 2019).

Sustainability is one of the most critical challenges and priorities of the modern world. It is also observed as a strategic trend in global environment protection policy and socio-economic development (Megyesiova and Lieskovska, 2018). Derlukiewiczet al. (2020) reported that the challenges of the present day and willingness to strive for sustainable development result in the creation of programs and projects supporting research and implementation of solutions that take into account economic, environmental and social aspects, and which may be motivators for other market participants.

Sustainability is more often identified in the pro-ecological context. However, it should be remembered that the area of the environment is not the only pillar of this concept. The other two pillars: society and economy are equally important. The three pillars of sustainability are fundamental and occur across all sectors of the economy (Derlukiewicz et al., 2020). It should be highlighted that sustainability recommends that the needs of the future can be met depending on how well social (equity, participation, empowerment, social mobility, and cultural preservation), economic (services, household needs, industrial growth, agriculture growth, and efficient use of labour), and environmental (biodiversity, natural resources, carrying capacity, ecosystem integrity, and clean air and water) objectives or needs are balanced.

2.4.1 Dimensions of sustainability

The dimensions of sustainability for manufacturing firms can be broadly categorized into three main pillars: environmental, social, and economic sustainability (Harik et al., 2015).

2.4.1.1 Environmental sustainability

Environmental sustainability is one of the essential principles of sustainability, which warrants that the quest for satisfying our needs should not compromise the quality of the environment, and the ecosystem should be sustained for the sake of future generations (Kaswan et al., 2019). Environmental sustainability is concerned with the maintenance of factors and practices that contribute to the quality of environment on a long-term basis. Ifeoma et al. (2020) described environmental sustainability as the process by which human and non-human activity on the environment is geared towards improving human living standards and protecting/preserving the environment. Achieving environmental sustainability requires exploiting sustainable practices for the provision of a product/service to the final customer, throughout the whole product life cycle, from the conception to the end-of-life. Indeed, from an environmental point of view, manufacturing and logistics activities can have a relevant impact, ranging from emissions into the environment, to the consumption of resources, up to the product end-of-life.

The convergence of the circular economy, which aim to enhance resource use efficiency (Feroz et al., 2021 and Sarc et al., 2019), has emphasized environmental sustainability. In the increasingly interconnected global world, stakeholders' relationships are redefined as the sustainability-based sharing economy (Cohen and Kietzmann, 2014). Incorporating environmental sustainability principles in operations can enhance organizations' value and make manufacturing more valuable (Ukko et al., 2019). Harik et al. (2015) highlighted key environmental sustainability dimensions and their associated measurement metrics include energy consumption and efficiency, water consumption and efficiency, material consumption and efficiency, waste generation and reduction, greenhouse gas emissions and

reduction, renewable energy usage, sustainable product design and development, closed loop manufacturing processes and sustainable resource management.

2.4.1.2 Economic sustainability

Wassan et al. (2023) identified the key aspect of economic sustainability in the manufacturing sector as the adoption of lean and fit manufacturing practices. Lean manufacturing, which aims to minimize waste and maximize efficiency, has been shown to have a positive impact on economic sustainability by reducing resource consumption, improving productivity, and enhancing competitiveness (Esmaeel and Sukati, 2015). Similarly, fit manufacturing, which focuses on aligning production processes with market demands, can also contribute to economic sustainability by enhancing a firm's ability to adapt to changing market conditions and maintain a competitive edge (Esmaeel and Sukati, 2015). Researchers such as (Jagani, 2023 and Fatoki, 2020) have also explored the role of specific strategies and practices in enhancing the economic sustainability of manufacturing firms. Hami et al. (2015) also highlighted the measurement of economic sustainability as financial performance and long-term viability of the manufacturing firms which includes such dimensions as profitability, productivity and innovation.

2.4.1.3 Social sustainability

The social dimension of sustainability is concerned with the well-being and quality of life of individuals and communities, as well as the equitable distribution of the benefits and burdens of development (Esmaeel and Sukati, 2015). In the context of manufacturing firms, social sustainability encompasses a range of issues, including worker rights and working conditions, community engagement, and the broader social impacts of manufacturing activities (Davis and Ramirez-Andreotta, 2021).

One key aspect of social sustainability in manufacturing is the treatment of workers. Manufacturers have been under increasing pressure to ensure fair labour practices, such as providing safe working conditions, fair wages, and opportunities for skill development and career advancement (Khokhar et al., 2020). Also, Sudusinghe and Seuring, (2020) and Fernando and Sutha (2022) have shown that adopting socially responsible labour practices can not only improve worker well-being but also contribute to enhanced productivity, employee retention, and overall business performance. Obamen et al. (2021) observed another critical aspect of social sustainability in manufacturing as the impact of manufacturing activities on local communities. Manufacturing can contribute to social sustainability by engaging with local stakeholders, supporting community development initiatives, and mitigating the negative social impacts of their operations, such as displacement, pollution, and disruption of local livelihoods (Obamen et al., 2021 and Fatoki, 2020). Hassan et al. (2016) regarded the social sustainability dimension focuses on the impact of manufacturing operations on employees, customers, and the surrounding community. This dimension includes aspects such as employee well-being, customer satisfaction and community engagement.

2.5 Theoretical framework of the study

Dynamic Capability Theory (DCT), as developed by Teece *et al*. (1997) is highly relevant as the theoretical framework for this study, which explores the link between eco-innovation and the long-term sustainability of packaging firms in Kogi State, Nigeria. DCT centers on a firm's ability to integrate, build and reconfigure internal and external resources to adapt to rapidly changing environments. This perspective aligns closely with the evolving nature of eco-innovation, which encompasses strategies such as collaboration, eco-engineering, green knowledge sharing and adherence to environmental regulations. Eco-innovation demands that firms continuously adapt their technologies, processes and relationships in response to environmental and market pressures. DCT provides a robust lens for understanding how these firms develop such adaptive capabilities. It highlights three core processes

sensing opportunities, seizing them and transforming organizational resources which are critical to embedding sustainable innovation in business operations.

Given the environmental challenges, regulatory changes and shifting consumer demands facing packaging firms in Kogi State, dynamic capabilities are essential for long-term competitiveness. These firms must innovate, build strategic partnerships and adopt sustainable practices to survive and thrive. DCT thus offers a practical framework to analyze how firms navigate these complex dynamics by leveraging eco-innovation as a strategic capability. Moreover, DCT enables the study to go beyond static resource-based views by focusing on how organizations learn, adapt and evolve over time to maintain relevance and sustainability. It also supports strategic decision-making by illuminating the processes through which firms embed eco-innovation into their core competencies. With its wide application in studies on green innovation and corporate sustainability, DCT provides strong empirical and theoretical grounding for this research.

3.0 Methodology

This study adopted a quantitative survey research design to test the hypothesized relationships between econ-innovation and sustainability of plastic packing firms in Abuja. However, the target population for this study comprises 174 respondents drawn from 31 plastics manufacturing firms in Kogi State as obtained from the State bureau of statistic (2024). To attain a sample size that sufficiently captured the goals of the study, the study adopted a census-based method because the sample frame was small. Therefore, in order to have a robust survey, 174 top and middle management staff from 31 plastics manufacturing firms were selected. The instrument for the study was validated by experts and adjudged adequate with a 0.80 coefficient. Likert scale semi structured five points questionnaire was the primary instrument used for the study, complemented with google form. The study was analysed with descriptive and inferential statistics via multiple regression at 0.05 level of significance.

4.0 Results and Discussion

The data collected were analysed using descriptive and inferential statistics in this section. The research used Ordinary Least Square regression to test the hypothesized effects developed to guide the study.

Table 4.1: Distribution by Response Rate

Questionnaire Status	Frequency	Percentage (%)
Administered	174	100
Returned	169	97.1
Unreturned	5	2.9

Out of a total of 174 questionnaires administered, 169 were successfully returned, representing a high response rate of **96%,** while only 7 questionnaires were not returned, accounting for **4%.** This high return rate suggests that the data collected is reliable and adequately representative of the target population.

Table 4.2: Age Distribution of Respondents

Age Group (Years)	Frequency (%)
20 – 30	22.16%

Age Group (Years)	Frequency (%)
31 – 40	47.16%
41 – 50	22.16%
51 and above	3.41%
Total	**100%**

The data in table 4.2 shows that the largest proportion of respondents (47.16%) fall within the 31–40 years age bracket, indicating a dominance of middle-aged, mature individuals in the study sample. The presence of respondents across all age groups also reflects a fairly diverse representation, though younger (20–30) and older (51+) age groups are less represented. The dominance of the 31–40 age group suggests that the study findings are likely shaped by respondents with considerable experience and stable life stages, which may enhance the credibility and depth of the responses.

Table 4.3: Gender Distribution of Respondents

Gender	Frequency	Percentage (%)
Male	120	71.9%
Female	47	28.1%
Total	**167**	**100%**

Table 4.3 shows the response rate of the administered questionnaires. Out of the 174 questionnaires distributed, 169 were successfully returned, representing a high response rate of **97.1%.** Only 5 questionnaires were not returned, accounting for **2.9%.** This high response rate indicates strong participation and suggests that the data collected is likely to be reliable and representative of the target population.

4.1 Regression Analysis

4.4 Interpretation and Implication of the Regression Results

Variable	Coefficient (Coef.)	P-value
COL (Collaboration)	0.183	0.000
ECO (Eco-engineering)	0.075	0.021
GKS (Green Knowledge Sharing)	0.067	0.032
ERG (Environmental Regulation)	0.001	0.095
R^2 (Coefficient of Determination)	0.74	–

Interpretations

Ho1: Collaborative eco-innovation (COL) strategies does not significantly affect sustainable performance of plastic manufacturing firms. The c**oefficient (0.183)** indicates that collaboration has a **positive and relatively strong effect** on sustainability. For every unit increase in collaboration, sustainability increases by 0.183 units. The **P-value (0.000)** also shows a highly significant ($p < 0.01$) statistical effect of collaboration on sustainability and not due to chance. **Collaboration** is the most influential eco-innovation strategy and should be prioritized by packaging firms aiming for long-term sustainability (Babu *et al.*, 2025).

Ho2: Eco-engineering (ECO) practices does not significantly affect sustainable performance of plastic manufacturing firms. The **Coefficient 0.075** demonstrate a **positive effect** on sustainability, though smaller than collaboration. The **P-value (0.021)** is statistically significant and confirmed that eco-engineering meaningfully contributes to plastic firms sustainability. **Eco-engineering and green knowledge sharing** also play significant roles and should be integrated into business operations to enhance environmental performance (Chen 2024) .

Ho3: Green knowledge sharing (GKS) does not significantly affect sustainable performance of plastic manufacturing firms. The **Coefficient (0.067)** shows a positively influences sustainability, indicating that knowledge sharing on green practices improves firm sustainability. The **P-value (0.032)** was found statistically significant against the threshold ($p < 0.05$), so the relationship is reliable and is nine with donvention (Babu *et al.*, 2025).

Ho4: Environmental regulatory (ERG) does not significantly affect sustainable performance of plastic manufacturing firms. The **Coefficient (0.001)** indicates a **very weak effect** on sustainability. The **P-value (0.095) was** not statistically significant compare to ($p > 0.05$) threshold, suggesting that environmental regulation does not have a meaningful impact on sustainability in this context. **Environmental regulation,** while conceptually important, appears to have no significant influence in this sample—this might suggest weak enforcement or low compliance.

Coefficient of Determination revealed R^2 (0.71) value. This means that **71% of the variation** in sustainability can be explained by the four eco-innovation strategies combined (COL, ECO, GKS, ERG). This is a **high R^2**, indicating a good model fit and that the predictors jointly explain most of the outcome.

6.0 Conclusion and Recommendations

Based on the findings of this study, it is evident that eco-innovation strategies—particularly collaboration, eco-engineering, and green knowledge sharing—have significant positive effects on the sustainability of packaging firms in Kogi State, Nigeria. Among these, collaboration emerged as the most influential driver, highlighting the importance of strategic partnerships in achieving long-term environmental goals. While environmental regulation showed a minimal and statistically insignificant impact, the high R^2 value of 0.74 indicates that the model strongly explains the variation in sustainability outcomes. Therefore, firms that prioritize cooperative innovation, invest in green technologies, and promote internal knowledge sharing are more likely to achieve sustainable growth. These insights underscore the need for a strategic, integrated approach to eco-innovation in Nigeria's packaging industry.

Recommendations: Here are evidence-based recommendations from the study

1. Packaging firms should actively build strategic partnerships with suppliers, research institutions and environmental agencies to co-develop and implement sustainable solutions. These collaborations can

lead to resource sharing, joint innovation and faster adoption of green technologies enhancing long-term sustainability.

2. Firms should invest in redesigning their production processes and packaging systems to reduce environmental impact such as adopting biodegradable materials, energy-efficient machinery and closed-loop production systems. Eco-engineering not only lowers environmental costs but also creates competitive advantage.

3. Organizations should create platforms (e.g., internal seminars, digital knowledge hubs, cross-functional teams) for sharing green practices, innovations and lessons learned. Encouraging staff at all levels to contribute and learn about sustainability efforts can embed eco-consciousness into the organizational culture.

4. Although not statistically significant, firms should still comply proactively with environmental laws and seek ISO 14001 or related certifications, positioning themselves as responsible and forward-thinking. Additionally, advocacy for stronger and more consistent enforcement of environmental policies can level the playing field across the industry.

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