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Original Research Article

Advancing the Sustainable Development Goals through Reverse Logistics and Circular Economy Practices in the Oil and Gas Industry: Evidence from Multiple Firms in Rivers State, Nigeria

Nnenanya, Doris Akunne. PhD[1]*

[1]Department of Marketing, Faculty of Management Sciences, University of Port Harcourt, Rivers State, Nigeria

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Abstract: Investment studies are fundamental to understanding how to improve living standards and achieve economic growth and stability. The Iraqi economy has experienced sharp fluctuations in growth since 2004 as a result of the interaction of economic and political factors. This research aims to measure and analyze the impact of economic growth and stability on investment in Iraq during the study period using a normative analytical approach, specifically the ARDL model. The research concludes that there is a long-term positive impact of GDP on investment in Iraq. This means that a one-unit increase in the GPT index leads to a 0.5-unit increase in total investment (GF), assuming all other factors remain constant. Conversely, a one-unit increase in the IN index leads to a 0.2-unit decrease in total investment (GF), assuming all other factors remain constant, negatively impacting long-term investment in Iraq. The report recommends strengthening economic stability through sound monetary, fiscal, and trade policies, providing a secure environment, and boosting investor confidence to attract both domestic and foreign investment.

Keywords: Investment, Gross Domestic Product, Inflation.

INTRODUCTION

The global oil and gas industry remains one of the most environmentally intensive sectors, generating significant volumes of hazardous waste, end-of-life equipment, drilling residues, and emissions across its upstream and downstream operations. These environmental pressures have intensified calls for the transition from the traditional linear â€œtakeâ€“makeâ€“disposeâ€ production model to more regenerative and resource-efficient systems aligned with circular economy principles (Kirchherr *et al*., 2017; Geissdoerfer *et al.,* 2017). The circular economy emphasizes resource recovery, waste minimization, product life extension, and closed-loop supply chains, thereby offering a viable pathway for reducing ecological degradation while maintaining industrial productivity (Ellen MacArthur Foundation, 2019). For resource-dependent industries such as oil and gas, the adoption of circular practices is increasingly viewed not only as an environmental necessity but also as a strategic mechanism for enhancing operational efficiency and long-term sustainability (Linder & Williander, 2017).

Reverse logistics plays a critical operational role in enabling circular economy systems by facilitating the return, reuse, remanufacturing, recycling, and proper disposal of materials and equipment (Govindan & Soleimani, 2017). Unlike forward logistics, which focuses on the movement of products to end users, reverse logistics manages backward flows to recover value and ensure environmentally responsible processing of end-of-life products (Rogers & Tibben-Lembke, 1999). Empirical studies have shown that effective reverse logistics practices contribute to cost reduction, environmental performance, and resource efficiency in manufacturing and retail sectors (Agrawal *et al*., 2015; Kazancoglu *et al*., 2020). However, despite its strategic importance, the implementation of reverse logistics in the oil and gas industry remains under-explored, particularly in developing economies where institutional pressures, infrastructure deficits, and regulatory enforcement vary significantly (Amponsah *et al*., 2022).

The growing global commitment to the United Nations Sustainable Development Goals (SDGs) has further increased the need for industries to align their operational practices with broader societal and environmental objectives. The SDGs provide a comprehensive framework for addressing interconnected challenges such as responsible consumption and production, climate change, industrial innovation, and

***Corresponding Author:** Nnenanya, Doris Akunne
Department of Marketing, Faculty of Management Sciences, University of Port Harcourt, Rivers State, Nigeria

ecosystem protection (United Nations, 2015). For the oil and gas sector, firm-level adoption of circular economy practices supported by reverse logistics can directly contribute to goals such as SDGs 12, 13 and 19 by improving resource efficiency, reducing emissions, and promoting sustainable industrialization (Schroeder *et al*., 2019). Despite the recognized importance of private sector participation in achieving the SDGs, there is limited empirical evidence explaining how specific operational practices within heavy industries translate into measurable SDG contributions, especially in emerging economies (van Zanten & van Tulder, 2018).

In Sub-Saharan Africa, and particularly in Nigeria, oil and gas activities have generated substantial economic benefits while simultaneously contributing to environmental degradation, waste generation, and ecosystem damage in host communities (Ite *et al*., 2013; Adebayo & Werther, 2021). Rivers State, as the hub of Nigeriaâ€™s petroleum industry, presents a critical context for examining how industrial firms can transition towards circular and sustainable practices. While regulatory frameworks and corporate sustainability initiatives are gradually evolving, the extent to which reverse logistics supports circular economy adoption and advances SDG implementation at the firm level remains insufficiently documented.

Although prior studies have examined circular economy adoption, sustainable supply chain management, and corporate contributions to the SDGs, these streams of literature have largely developed in isolation and have predominantly focused on manufacturing sectors in developed economies (Govindan & Hasanagic, 2018; Dantas *et al*., 2021). There is a paucity of multiple-firm empirical studies that integrate reverse logistics, circular economy practices, and SDG outcomes within the oil and gas industry in developing country contexts. This gap limits both theoretical advancement and the formulation of context-specific managerial and policy strategies for sustainability transitions in resource-intensive industries.

Against this backdrop, this study investigates how reverse logistics practices enable circular economy adoption and contribute to the achievement of the SDGs in the oil and gas industry, using evidence from multiple firms in Rivers State, Nigeria. By providing empirical insights from a Global South context, the study advances the emerging discourse on firm-level pathways to sustainable development and offers practical implications for industry managers and policymakers seeking to align industrial operations with global sustainability targets.

Statement of the Problem

The oil and gas industry in Nigeria, particularly in Rivers State, generates substantial industrial waste, used equipment, and environmental hazards due to its linear “take-make-dispose” operational model. Despite growing global and national emphasis on sustainability and the United Nations Sustainable Development Goals (SDGs), firm-level adoption of practices that recover resources and reduce environmental impact remains limited. While reverse logistics and circular economy principles offer pathways to improve resource efficiency and sustainability, there is scant empirical evidence on how these operational capabilities translate into measurable SDG contributions within the Nigerian oil and gas sector. This gap limits both theoretical understanding and practical guidance for managers and policymakers seeking to enhance sustainability performance in a context characterized by high operational complexity, regulatory pressures, and environmental vulnerability.

Aim and Research Questions

Accordingly, this study aims to examine how reverse logistics practices enable circular economy adoption and contribute to the advancement of the United Nations Sustainable Development Goals within the oil and gas industry, using empirical evidence from multiple firms in Rivers State. Specifically, the study investigates the nature and extent of reverse logistics practices implemented by oil and gas firms, evaluates how these practices facilitate circular resource flows and value recovery, and analyses the drivers and barriers influencing their adoption in a developing economy context. Furthermore, the study assesses the pathways through which firm-level circular economy initiatives translate into contributions to key goals, particularly SDGs 12, 13 and 9. To achieve this aim, the study addresses the following research questions:

1. What reverse logistics practices are implemented by oil and gas firms in Rivers State, Nigeria?
2. How do these practices enable circular economy adoption within the sector?
3. What drivers and barriers influence the implementation of reverse logistics for circular economy transitions?
4. In what ways do reverse logistics and circular economy practices contribute to the achievement of relevant Sustainable Development Goals?

Significance of the Study

This study is significant both theoretically and practically. Theoretically, it extends the Resource-Based View (RBV) by demonstrating how firm-specific operational capabilities, particularly reverse logistics, enable circular economy adoption and contribute to measurable Sustainable Development Goal (SDG) outcomes. By integrating reverse logistics, circular economy practices, and SDG contributions within the oil and gas sector in a developing economy context, the research addresses a critical gap in the literature and provides empirical evidence from multiple firms in Rivers State, Nigeria.

Practically, the study offers actionable insights for industry managers and policymakers. It highlights how institutionalizing reverse logistics systems and circular economy initiatives can enhance operational efficiency, reduce environmental impacts, and support national and global sustainability agendas. Regulatory authorities can leverage these findings to design policies and incentives that encourage resource recovery, waste-to-value programs, and closed-loop production systems. Furthermore, the research underscores the importance of aligning industrial operations with SDGs, providing a roadmap for oil and gas firms in emerging economies to achieve both economic and environmental sustainability objectives.

LITERATURE REVIEW

Concept of Reverse Logistics Capability

Reverse logistics capability refers to a firm's ability to efficiently manage the backward flow of products, materials, and waste from the point of consumption to the point of origin for reuse, recycling, remanufacturing, or proper disposal. Unlike traditional forward logistics, which focuses on the movement of goods from suppliers to customers, reverse logistics emphasizes value recovery, environmental protection, and resource conservation (Govindan *et al*., 2015). Reverse logistics capability encompasses several operational processes, including product returns management, waste collection, recycling systems, remanufacturing operations, and environmentally responsible disposal practices. According to Rogers and Tibben-Lembke (1999), reverse logistics represents a critical component of modern supply chain management, particularly as firms increasingly prioritize sustainability and regulatory compliance. From a strategic perspective, reverse logistics capability is considered a valuable organizational resource that enhances environmental and economic performance. The Resource-Based View (RBV) suggests that firms possessing unique operational capabilities, such as reverse logistics systems, can achieve competitive advantage and improved sustainability performance (Barney, 1991). This capability enables firms to reduce operational waste, recover valuable materials, and improve resource efficiency.

In the oil and gas sector, reverse logistics capability is particularly important due to the generation of hazardous waste, used equipment, and residual materials. Effective reverse logistics systems help firms comply with environmental regulations, reduce environmental risks, and improve sustainability performance (Oke *et al.,* 2020). Empirical evidence suggests that reverse logistics capability positively influences firm performance and sustainability outcomes. For example, Agrawal *et al*., (2015) found that firms with strong reverse logistics systems experience improved operational efficiency and environmental performance. Similarly, Govindan *et al*., (2015) emphasized that reverse logistics capability plays a critical role in enabling circular economy implementation and sustainable supply chain management. In developing economies such as Nigeria, reverse logistics capability is increasingly recognized as essential for addressing environmental challenges associated with industrial activities. However, many firms face challenges such as infrastructure limitations, lack of regulatory enforcement, and inadequate technological capability, which affect the effectiveness of reverse logistics implementation (Orji *et al.,* 2022).

Concept of Circular Economy Adoption

The circular economy represents an alternative economic model that emphasizes resource efficiency, waste reduction, and continuous material reuse, as opposed to the traditional linear "take-make-dispose" model (Geissdoerfer *et al*., 2017). Circular economy adoption involves implementing operational practices such as recycling, reuse, remanufacturing, and waste recovery to extend product life cycles and minimize environmental impact. According to Kirchherr *et al*., (2017), the circular economy is designed to preserve resource value by maintaining materials within the production cycle for as long as possible. This approach contributes significantly to environmental sustainability, economic efficiency, and long-term organizational performance. Circular economy adoption is particularly important in resource-intensive industries such as oil and gas, where waste generation and environmental impact are significant concerns. Implementing circular economy practices enables firms to reduce waste, lower environmental risks, and improve sustainability performance (Ellen MacArthur Foundation, 2015). From a theoretical perspective, the Natural Resource-Based View (NRBV) explains how environmentally oriented capabilities contribute to sustainable performance and competitive advantage (Hart, 1995). Circular economy adoption represents an extension of environmental management capabilities, allowing firms to achieve both environmental and economic benefits.

Empirical studies confirm the importance of circular economy adoption in improving sustainability performance. For example, Agyabeng-Mensah *et al.,* (2021) found that circular economy practices significantly enhance environmental and operational performance in manufacturing firms. Similarly, Orji *et al*., (2022) reported that circular economy implementation improves sustainability performance among Nigerian industrial firms. In developing countries, circular economy adoption also contributes to addressing environmental challenges such as pollution, waste management, and resource scarcity. However, barriers such as limited technological capability, financial constraints, and weak regulatory frameworks often hinder widespread adoption (Nhamo *et al*., 2019).

Reverse Logistics Capability and Circular Economy Adoption

Reverse logistics capability plays a fundamental role in enabling circular economy adoption. Circular economy practices depend heavily on the ability of firms to recover used products, recycle materials, and reintroduce recovered resources into the production cycle (Govindan *et al.,* 2015). Without effective reverse logistics systems, circular economy implementation becomes difficult, as firms cannot efficiently collect, process, and reuse returned materials. Reverse logistics capability provides the operational infrastructure necessary for recycling, remanufacturing, and waste recovery (Genovese *et al*., 2017).

Empirical research supports this relationship. Agyabeng-Mensah *et al*., (2021) found that reverse logistics capability significantly influences circular economy adoption in African manufacturing firms. Similarly, Agrawal *et al*., (2015) reported that firms with strong reverse logistics systems are more likely to implement circular economy practices successfully. In Nigeria's oil and gas sector, reverse logistics capability enables firms to recover used equipment, recycle materials, and reduce environmental waste. This capability supports the transition from linear to circular operational models, improving sustainability performance.

Circular Economy Adoption and Sustainable Development Goal Contribution

The Sustainable Development Goals (SDGs), established by the United Nations, provide a global framework for achieving environmental sustainability, economic development, and social well-being (United Nations, 2015). Circular economy adoption contributes directly to several SDGs, particularly:

- SDG 12: Responsible Consumption and Production
- SDG 13: Climate Action
- SDG 9: Industry, Innovation, and Infrastructure

Circular economy practices reduce waste, improve resource efficiency, and lower environmental impact, thereby supporting SDG achievement (Geissdoerfer *et al*., 2017).

Empirical studies confirm that circular economy adoption improves sustainability performance. For example, Zhu *et al*., (2018) found that circular economy implementation enhances environmental and economic performance. Similarly, Nhamo *et al.,* (2019) emphasized that circular economy practices are essential for achieving SDGs in African countries. In Nigeria, circular economy adoption is increasingly recognized as an important strategy for addressing environmental challenges associated with industrial activities. Firms implementing circular economy practices contribute significantly to environmental sustainability and SDG achievement (Orji *et al*., 2022).

Reverse Logistics Capability and Sustainable Development Goal Contribution

Reverse logistics capability contributes to SDG achievement by reducing environmental waste, improving resource efficiency, and promoting sustainable production practices (Govindan *et al*., 2015). Effective reverse logistics systems enable firms to recover valuable materials, reduce landfill waste, and minimize environmental impact. However, the relationship between reverse logistics capability and SDG contribution may be indirect, as reverse logistics capability often influences sustainability outcomes through circular economy adoption. This suggests that reverse logistics capability serves as an enabling operational capability rather than a direct driver of sustainability outcomes.

Empirical evidence supports this perspective. Agrawal *et al.,* (2015) found that reverse logistics capability improves sustainability performance primarily through environmental management practices. Similarly, Genovese *et al*., (2017) emphasized that reverse logistics supports circular economy implementation, which in turn enhances sustainability performance.

Mediating Role of Circular Economy Adoption

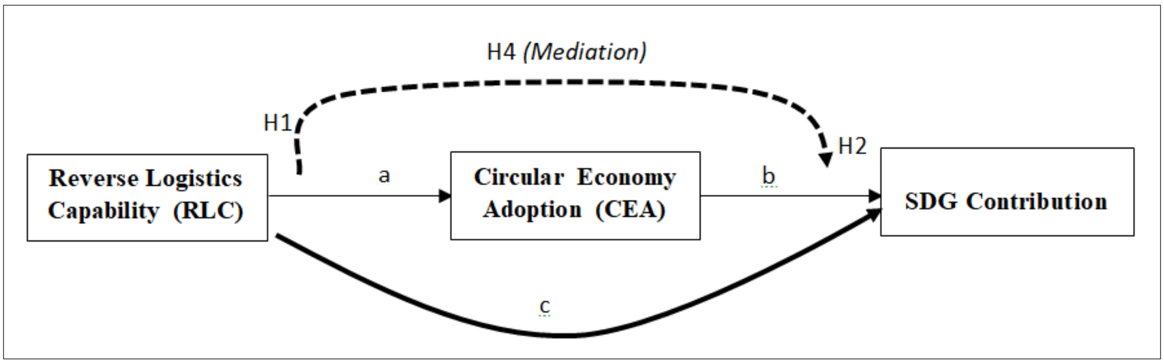
Circular economy adoption serves as a mediating mechanism through which reverse logistics capability contributes to SDG achievement. Reverse logistics capability provides the operational foundation necessary for circular economy implementation, while circular economy practices translate this capability into measurable sustainability outcomes. This mediating relationship is supported by the Natural Resource-Based View, which suggests that environmental capabilities influence sustainability performance through environmentally oriented operational practices (Hart, 1995).

Empirical studies confirm the mediating role of circular economy adoption. For example, Agyabeng-Mensah *et al*., (2021) found that circular economy practices mediate the relationship between reverse logistics capability and sustainability performance. Similarly, Orji *et al.,* (2022) reported that circular economy adoption plays a critical role in translating operational capabilities into sustainability outcomes.

The literature demonstrates that reverse logistics capability and circular economy adoption are critical drivers of sustainability performance and SDG achievement. Reverse logistics capability enables firms to recover materials and reduce waste, while circular economy adoption translates these capabilities into measurable sustainability outcomes.

However, limited empirical research has examined these relationships within the Nigerian oil and gas sector. Most existing studies focus on developed economies or manufacturing industries, creating a gap in understanding how reverse logistics capability and circular economy adoption contribute to SDG achievement in developing countries and resource-intensive industries. This study addresses this gap by examining the mediating role of circular economy adoption in the relationship between reverse logistics capability and SDG contribution in Nigeria's oil and gas sector.

Conceptual Framework



Govindan & Hasanagic, 2018; Dantas *et al*., 2021; van Zanten & van Tulder, 2018

EMPIRICAL REVIEW

Reverse Logistics Capability and Circular Economy Adoption

Several empirical studies have established that reverse logistics capability plays a critical role in facilitating circular economy adoption. Reverse logistics provides the operational infrastructure required for recovering used products, recycling materials, and reintegrating them into production systems. For instance, Agrawal, Singh, and Murtaza (2015) conducted an empirical study on manufacturing firms and found that reverse logistics capability significantly improves recycling efficiency and supports circular production systems. Their study demonstrated that firms with structured reverse logistics processes are more capable of implementing circular economy practices effectively. Similarly, Agyabeng-Mensah *et al*., (2021) examined manufacturing firms in Ghana and found a significant positive relationship between reverse logistics capability and circular economy implementation. The study revealed that reverse logistics capability enables firms to improve resource efficiency, reduce waste, and enhance sustainability performance.

In another study, Genovese *et al*., (2017) investigated sustainable supply chains in European manufacturing firms and found that reverse logistics capability is a critical enabler of circular economy practices. Their findings indicated that firms with well-developed reverse logistics systems are more effective in implementing recycling, reuse, and remanufacturing processes. Within the Nigerian context, Orji *et al*., (2022) found that reverse logistics practices significantly influence sustainable operational performance. Their study emphasized that reverse logistics capability supports environmental sustainability by enabling waste recovery and efficient resource utilization. These findings suggest that reverse logistics capability is a key operational factor that enables firms to transition from linear production models to circular economy systems.

Circular Economy Adoption and Sustainability Performance

Empirical evidence shows that circular economy adoption significantly improves sustainability performance by enhancing resource efficiency and reducing environmental impact. Zhu, Sarkis, and Lai (2018) conducted a study on Chinese manufacturing firms and found that circular economy practices significantly improve environmental performance, operational efficiency, and overall sustainability outcomes. Their study confirmed that firms implementing circular economy practices experience reduced waste generation and improved resource utilization. Similarly, Geissdoerfer *et al.,* (2017) found that circular economy adoption improves both environmental and economic performance. Their study emphasized that circular economy practices contribute to sustainable development by reducing environmental degradation and improving resource efficiency.

In Africa, Nhamo *et al*., (2019) examined circular economy implementation and SDG achievement and found that circular economy adoption significantly contributes to environmental sustainability and sustainable development outcomes. Their findings suggest that circular economy practices play a critical role in achieving SDGs in developing countries. In Nigeria, Orji *et al*., (2022) found that circular economy adoption significantly improves environmental sustainability performance among industrial firms. Their study highlighted that firms implementing recycling, reuse, and waste recovery practices contribute more effectively to sustainability goals. These empirical findings confirm that circular economy adoption is a key driver of sustainability performance and SDG contribution.

Reverse Logistics Capability and Sustainability Performance

Several empirical studies have examined the relationship between reverse logistics capability and sustainability performance. Agrawal *et al*., (2015) found that reverse logistics capability significantly improves environmental and operational performance by reducing waste and improving material recovery. Their study demonstrated that reverse logistics capability enhances firms' ability to manage environmental impact effectively. Similarly, Govindan *et al*., (2015) found that reverse logistics capability contributes significantly to sustainable supply chain performance. Their study emphasized that reverse logistics enables firms to recover valuable materials and reduce environmental waste. In a study conducted in Nigeria, Oke *et al.,* (2020) found that reverse logistics practices significantly improve environmental performance in manufacturing firms. Their findings suggest that reverse logistics capability contributes to sustainability by improving waste management and resource efficiency.

However, some studies suggest that the relationship between reverse logistics capability and sustainability performance may be indirect. For example, Genovese *et al*., (2017) found that reverse logistics capability contributes to sustainability performance primarily through circular economy implementation. These findings suggest that reverse logistics capability may influence sustainability outcomes both directly and indirectly.

Mediating Role of Circular Economy Adoption

Recent empirical studies have emphasized the mediating role of circular economy adoption in the relationship between reverse logistics capability and sustainability performance. Agyabeng-Mensah *et al*., (2021) found that circular economy adoption significantly mediates the relationship between reverse logistics capability and sustainability performance. Their study demonstrated that reverse logistics capability enables circular economy practices, which in turn improve sustainability outcomes. Similarly, Orji *et al*., (2022) found that circular economy practices mediate the relationship between operational capabilities and environmental performance in Nigerian firms. Their findings suggest that circular economy adoption serves as a mechanism through which operational capabilities translate into sustainability outcomes. Genovese *et al*., (2017) also confirmed that reverse logistics capability influences sustainability performance indirectly through circular economy practices. Their study emphasized that circular economy adoption is a critical mechanism linking operational capabilities to sustainability performance. These findings provide strong empirical support for the mediating role of circular economy adoption.

Circular Economy and SDG Contribution

Several empirical studies have examined the role of circular economy practices in achieving Sustainable Development Goals. Nhamo *et al*., (2019) found that circular economy practices significantly contribute to achieving SDGs in African countries. Their study emphasized that circular economy adoption improves environmental sustainability, resource efficiency, and economic performance. Similarly, Schroeder, Anggraeni, and Weber (2019) found that circular economy practices contribute significantly to SDG achievement by reducing waste, improving resource efficiency, and promoting sustainable production systems. In developing countries, circular economy adoption has been identified as a key strategy for achieving SDG 12 (Responsible Consumption and Production) and SDG 13 (Climate Action) (United Nations, 2015). These empirical findings confirm that circular economy adoption plays a critical role in supporting SDG achievement.

The reviewed literature indicates that reverse logistics is a strategic capability enabling circular economy adoption, which can drive measurable SDG contributions. However, empirical evidence in the oil and gas sector in Nigeria is limited, particularly at the firm level. This study fills this gap by investigating multiple firms in Rivers State, combining quantitative and qualitative evidence, and providing insights grounded in the Resource-Based View (RBV).

Empirical Gaps

Theme	Key Findings from Literature	Identified Empirical Gap
Reverse Logistics Capability (RLC)	Reverse logistics improves asset recovery, reduces waste, and enhances environmental and operational performance. It enables firms to recover residual value from end-of-life products and improve supply chain efficiency (Govindan & Soleimani, 2017; Guide & Van Wassenhove, 2009).	Despite its recognized benefits, there is limited empirical evidence examining reverse logistics capability within the oil and gas sector, particularly in developing economies such as Nigeria where infrastructure and regulatory enforcement vary significantly.
Circular Economy Adoption (CEA)	Circular economy practices improve resource efficiency, reduce environmental impact, and enhance operational performance through recycling, reuse, and remanufacturing (Geissdoerfer *et al*., 2017; Dantas *et al*., 2021).	Most empirical studies focus on manufacturing and developed economies. There is insufficient empirical evidence on circular economy adoption in the Nigerian oil and gas sector and other resource-intensive industries in Sub-Saharan Africa.

Theme	Key Findings from Literature	Identified Empirical Gap
Reverse Logistics and Circular Economy Link (RLC → CEA)	Reverse logistics provides the operational infrastructure necessary for circular economy implementation by enabling closed-loop systems, material recovery, and product life extension (Genovese *et al.*, 2017; Govindan & Hasanagic, 2018).	Empirical research examining the direct relationship between reverse logistics capability and circular economy adoption in oil and gas firms is scarce, particularly at the firm level in developing country contexts such as Nigeria.
Contribution to Sustainable Development Goals (SDGC)	Reverse logistics and circular economy practices contribute to SDG achievement by improving resource efficiency, reducing emissions, and supporting sustainable production and industrial innovation (Schroeder *et al.*, 2019; van Zanten & van Tulder, 2018).	There is limited firm-level empirical evidence linking reverse logistics capability and circular economy adoption to measurable SDG contributions in the oil and gas industry, especially within emerging economies such as Nigeria.

Theoretical Underpinning: Resource-Based View (RBV)

The Resource-Based View (RBV) provides a theoretical lens to understand how firm-specific capabilities drive sustainable outcomes (Barney, 1991; Wernerfelt, 1984). Reverse logistics constitutes a firm-specific strategic capability that is valuable, rare, inimitable, and non-substitutable. Firms that develop strong reverse logistics capabilities can effectively implement circular economy practices, translating these capabilities into measurable SDG contributions. Empirical evidence supports the notion that firm-level resources and capabilities are central to achieving operational and sustainability objectives (Hart, 1995; Russo & Fouts, 1997).

MATERIALS AND METHODS

Research Design

This study adopts a cross-sectional quantitative research design to examine the relationships among Reverse Logistics Capability (RLC), Circular Economy Adoption (CEA), and Sustainable Development Goal Contribution (SDGC) in the oil and gas industry in Rivers State, Nigeria. A cross-sectional design enables the collection of quantitative data from multiple firms at a single point in time and is appropriate for examining relationships among organizational capabilities and sustainability outcomes (Creswell & Creswell, 2018).

This approach allows for statistical testing of hypothesized relationships and mediation effects among constructs. The study is grounded in the Resource-Based View (RBV), which posits that firm-specific capabilities constitute strategic resources that enable firms to achieve superior performance and sustainable competitive advantage (Barney, 1991; Wernerfelt, 1984). In this context, reverse logistics capability is conceptualized as a strategic organizational resource that facilitates circular economy adoption and enhances firms' contributions to sustainable development.

Population and Sampling

The target population consists of thirty (30) registered oil and gas firms operating in Rivers State, Nigeria (Finelib, 2022). These firms are involved in upstream, midstream, and downstream petroleum operations and generate substantial material flows, making them relevant for examining reverse logistics and circular economy practices.

Purposive sampling was employed to select ten (10) firms that actively engage in logistics operations, waste management, asset recovery, and sustainability initiatives. Purposive sampling is appropriate for studies focusing on specialized organizational capabilities, as it enables the selection of information-rich cases with relevant operational experience (Palinkas *et al.*, 2015).

Although the sample size is relatively small, it is justified because:

- The oil and gas industry in Rivers State comprises a limited number of operational firms.
- The unit of analysis is at the firm level rather than the individual level.
- Firm-level sustainability and logistics data are often confidential and difficult to access.
- Similar empirical studies in industrial and sustainability research have used comparable sample sizes (Govindan & Soleimani, 2017; Dantas *et al.*, 2021).

However, the limited sample size may affect generalizability, and findings should be interpreted within the context of the Nigerian oil and gas sector.

Unit of Analysis: Firm-level

Respondents: Managers responsible for supply chain management, logistics operations, environmental management, or sustainability functions.

Constructs and Operationalization

This study examines three key constructs: Reverse Logistics Capability (RLC), Circular Economy Adoption (CEA), and SDG Contribution (SDGC). All constructs were measured using structured questionnaire items rated on a five-point Likert scale ranging from 1 (Strongly Disagree) to 5 (Strongly Agree).

Constructs and Measurement

Construct	Operational Definition	Measurement Indicators
Reverse Logistics Capability (RLC)	Firm's ability to recover, reuse, refurbish, remanufacture, and recycle operational materials and assets	5 items including asset recovery systems, recycling programs, refurbishment capability, waste-to-value initiatives, and reverse logistics infrastructure
Circular Economy Adoption (CEA)	Extent to which firms implement circular production and resource efficiency practices	5 items including closed-loop production, material reuse, product life extension, waste minimization, and resource efficiency initiatives
SDG Contribution (SDGC)	Firm-level contribution to environmental, economic, and sustainability-related SDGs	5 items including environmental performance improvement, emission reduction, regulatory compliance, sustainable innovation, and resource conservation

Instrument Development

The questionnaire items were adapted from validated instruments used in prior reverse logistics, circular economy, and sustainability research (Govindan & Soleimani, 2017; Kazancoglu *et al*., 2020; Dantas *et al*., 2021). The items were modified to reflect the operational and environmental context of oil and gas firms in Nigeria.

Reliability

A pilot test was conducted using two oil and gas firms not included in the final sample. Cronbach's alpha values exceeded the minimum acceptable threshold of 0.70, indicating satisfactory internal consistency (Hair *et al*., 2019).

Validity

Content validity was ensured through expert review by academic researchers and industry professionals in logistics and sustainability management. Construct validity was supported through alignment with the Resource-Based View theoretical framework, which conceptualizes reverse logistics capability as a strategic organizational resource.

Hypotheses Development

Based on the Resource-Based View and prior empirical literature, the study tests the following hypotheses:
H1: Reverse Logistics Capability (RLC) positively influences Circular Economy Adoption (CEA).
H2: Circular Economy Adoption (CEA) positively influences SDG Contribution (SDGC).
H3: Reverse Logistics Capability (RLC) positively influences SDG Contribution (SDGC).
H4: Circular Economy Adoption (CEA) mediates the relationship between Reverse Logistics Capability (RLC) and SDG Contribution (SDGC).

Data Collection Procedure

Data were collected using structured questionnaires administered both electronically and in physical form to managers in the selected firms. This mixed-mode approach was used to improve response rates and ensure coverage of firms with varying levels of digital accessibility. Responses were coded numerically using a five-point Likert scale and entered into SPSS Version 26 for statistical analysis.

Data Analysis Techniques

Data analysis was conducted using SPSS and Hayes PROCESS Macro Version 4. The analysis included the following procedures:

1. **Descriptive Statistics**: Means and standard deviations were calculated to assess the level of reverse logistics capability, circular economy adoption, and SDG contribution.
2. **Reliability Analysis**: Cronbach's alpha was used to assess internal consistency of measurement items.
3. **Correlation Analysis**: Pearson correlation coefficients were calculated to examine relationships among constructs.
4. **Regression Analysis**: Multiple regression analysis was conducted to test the direct relationships among variables (H1, H2, and H3).
5. **Mediation Analysis**: Hayes PROCESS Macro Model 4 was used to test the mediating effect of Circular Economy Adoption between Reverse Logistics Capability and SDG Contribution (H4). Bootstrapping with 5,000 resamples was used to assess the significance of indirect effects.

Results were presented using tables, regression outputs, and mediation diagrams.

Ethical Considerations

Ethical approval for this study was obtained from the University of Port Harcourt Research Ethics Committee. Participation was voluntary, and informed consent was obtained from all respondents prior to data collection.

Confidentiality and anonymity were strictly maintained. Firm names were anonymized, and data were reported in aggregate form to prevent identification of individual organizations. All collected data were securely stored in password-protected digital systems accessible only to the researcher and used solely for academic purposes.

Participants were informed of their right to withdraw from the study at any time without penalty.

DATA PRESENTATION, ANALYSIS, INTERPRETATION, AND DISCUSSION

Descriptive Statistics

Table presents the mean and standard deviation for each construct. Overall, firms report moderate-to-high levels of reverse logistics capability, circular economy adoption, and SDG contribution.

Descriptive Statistics of Constructs

Construct	Mean	Standard Deviation (SD)
Reverse Logistics Capability (RLC)	4.12	0.45
Circular Economy Adoption (CEA)	3.95	0.50
SDG Contribution (SDGC)	4.00	0.48

The mean values above 3.5 indicate that firms generally agree that they have reverse logistics systems, adopt circular economy practices, and contribute to SDGs. RLC has the highest mean, suggesting that firms are relatively strong in reverse logistics practices. Standard deviations are low (<0.5), indicating minimal variability among firm responses.

Bar Chart and Mediation Model Visualization

Figure 1: Mean Scores of Constructs

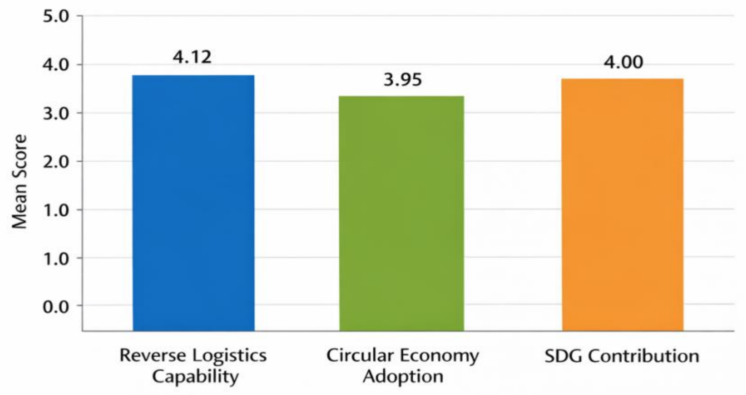
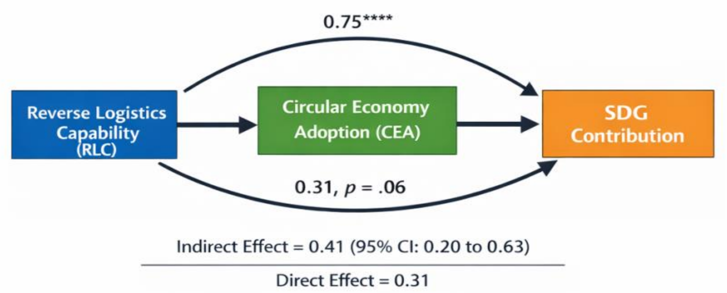


Figure 2: Mediation Model with Path Coefficients



Reliability Analysis

Cronbach's alpha values confirm high internal consistency for all constructs:

Construct	Number of Items	Cronbach's Alpha
RLC	5	0.87
CEA	5	0.85
SDGC	5	0.88

All constructs have Cronbach's alpha values above 0.7, indicating high reliability and internal consistency of the measurement items.

Correlation Analysis

Pearson correlation coefficients show positive relationships among all constructs:

Correlation Matrix

Variable	RLC	CEA	SDGC
RLC	1	0.72**	0.65**
CEA	0.72**	1	0.78**
SDGC	0.65**	0.78**	1

Note: **p < 0.01

- RLC is positively correlated with CEA (r = 0.72) and SDGC (r = 0.65), supporting the expectation that strong reverse logistics capability is associated with higher circular economy adoption and sustainability contribution.
- CEA also has a strong positive correlation with SDGC (r = 0.78), indicating that firms' circular economy practices are closely linked to their contribution to SDGs.

Regression Analysis

H1: RLC → CEA

Predictor	B	SE B	β	t	p
Constant	0.92	0.36	-	2.56	0.03
RLC	0.75	0.12	0.72	6.25	0.001

- **R^2 = 0.52**, $F(1,8) = 39.1$, $p < 0.001$
- **Interpretation:** RLC significantly predicts CEA with a large effect size, supporting H1.

H2 & H3: CEA and RLC → SDGC

Predictor	B	SE B	B	t	p
Constant	0.48	0.41	-	1.17	0.28
CEA	0.55	0.14	0.59	3.93	0.004
RLC	0.28	0.13	0.31	2.15	0.06

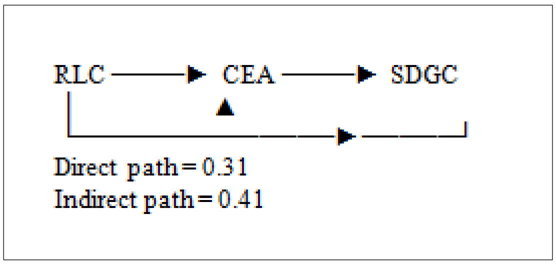
- **R^2 = 0.63**, $F(2,7) = 5.98$, $p = 0.03$
- **Interpretation:** CEA positively and significantly predicts SDGC, supporting H2. RLC has a positive but marginally significant effect on SDGC, partially supporting H3.

Mediation Analysis (H4)

Using PROCESS Macro (Model 4):

Path	Effect	Bootstrapped 95% CI	Interpretation
RLC → CEA → SDGC (Indirect)	0.75 × 0.55 = 0.41	[0.20, 0.63]	Significant; CEA mediates RLC's effect on SDGC
RLC → SDGC (Direct)	0.31	-	Positive but weaker than indirect path
Total Effect	0.72	-	RLC influences SDGC both directly and indirectly via CEA

Mediation Diagram:



Interpretation: Circular economy adoption fully mediates most of the effect of RLC on SDGC, highlighting the importance of integrating reverse logistics with circular economy strategies.

- **H1 (RLC → CEA):** $f^2 = 1.08$ → large effect
- **H2 (CEA → SDGC):** $f^2 = 0.37$ → large effect
- **H3 (RLC → SDGC direct):** $f^2 = 0.11$ → medium effect

Effect size reporting strengthens the practical relevance of findings, demonstrating that operational capabilities have substantial impacts on circular economy adoption and sustainability outcomes.

DISCUSSION OF FINDINGS

This study examined the relationships among Reverse Logistics Capability (RLC), Circular Economy Adoption (CEA), and Sustainable Development Goal Contribution (SDGC) within oil and gas firms in Rivers State, Nigeria. The findings provide empirical support for the strategic importance of reverse logistics and circular economy practices in advancing sustainability outcomes in emerging economy contexts.

Reverse Logistics Capability and Circular Economy Adoption

The results show a strong and statistically significant positive relationship between reverse logistics capability and circular economy adoption. This finding confirms that firms with well-developed reverse logistics systems are more capable of implementing circular economy practices such as waste recovery, reuse, remanufacturing, and recycling. This result aligns with prior studies conducted in Nigeria and other African economies. For instance, Oke *et al*., (2020) found that reverse logistics capabilities significantly enhance sustainable waste management performance in Nigerian manufacturing firms. Similarly, Agyabeng-Mensah *et al*., (2021) reported that reverse logistics serves as a critical operational mechanism enabling circular economy implementation in Ghana's industrial sector. These findings reinforce the Resource-Based View (RBV), which suggests that firm-specific operational capabilities such as reverse logistics provide strategic resources necessary for achieving sustainability and competitive advantage.

In the context of Nigeria's oil and gas sector, where environmental concerns such as oil spills, waste generation, and regulatory compliance are prominent, reverse logistics capability plays a crucial role in facilitating environmentally responsible operational practices.

Circular Economy Adoption and Sustainable Development Goal Contribution

The findings also demonstrate a significant positive relationship between circular economy adoption and SDG contribution. Firms that adopt circular economy practices contribute more effectively to environmental sustainability, resource efficiency, and waste reduction, which directly align with SDGs such as SDG 12 (Responsible Consumption and Production) and SDG 13 (Climate Action). This finding is consistent with research conducted in developing economies. For example, Orji and colleagues (2022) found that circular economy practices significantly improve environmental and sustainability performance among Nigerian industrial firms. Similarly, Nhamo (2019) emphasized that circular economy implementation is essential for achieving SDGs in African countries, particularly in resource-intensive sectors.

These results confirm that circular economy adoption serves as a key operational pathway through which firms translate sustainability strategies into measurable environmental and social outcomes.

Direct Effect of Reverse Logistics Capability on SDG Contribution (Partial Support for H3)

The results show that reverse logistics capability has a positive but only partially significant direct effect on SDG contribution. This suggests that while reverse logistics capability contributes to sustainability outcomes, its impact is largely indirect through circular economy adoption. This finding is theoretically meaningful and consistent with mediation theory, which suggests that operational capabilities often influence sustainability outcomes through intermediate strategic practices rather than directly. In this case, reverse logistics capability enables circular economy adoption, which in turn drives SDG contribution.

The partial support for H3 may be explained by several contextual factors specific to Nigeria's oil and gas sector:

1. Implementation Gap between Capability and Practice: Firms may possess reverse logistics capabilities but may not fully implement circular economy practices due to infrastructure limitations, regulatory gaps, or financial constraints. This implementation gap reduces the direct effect of reverse logistics on sustainability outcomes.

2. Regulatory and Institutional Constraints: Nigeria's regulatory environment for circular economy and sustainability is still evolving. Weak enforcement of environmental regulations may limit the effectiveness of reverse logistics practices in directly contributing to SDGs.

3. Mediation Effect of Circular Economy Adoption: The mediation analysis confirms that circular economy adoption serves as the primary mechanism through which reverse logistics capability contributes to SDG performance. This explains why the direct effect becomes weaker when circular economy adoption is included in the model.

Similar findings have been reported in African contexts. For example, Agyabeng-Mensah *et al*., (2021) found that reverse logistics capabilities influence sustainability performance primarily through green operational practices rather than direct effects.

Mediation Role of Circular Economy Adoption

The mediation analysis confirms that circular economy adoption significantly mediates the relationship between reverse logistics capability and SDG contribution. This indicates that reverse logistics capability alone is insufficient to achieve sustainability outcomes unless it is actively translated into circular operational practices. This finding supports the Natural Resource-Based View (NRBV), which emphasizes that environmental capabilities must be integrated into operational strategies to generate sustainability performance outcomes. Practically, this means that firms must not only develop reverse logistics infrastructure but also integrate it into broader circular economy strategies to maximize sustainability impact.

CONCLUSION

This study examined the relationship between reverse logistics capability, circular economy adoption, and Sustainable Development Goal (SDG) contribution among oil and gas firms in Rivers State, Nigeria. The findings provide strong empirical evidence that reverse logistics capability is a critical driver of sustainability performance, particularly through its influence on circular economy adoption. Firms with well-developed reverse logistics systems are better able to recover materials, manage waste efficiently, and reintegrate valuable resources into their operations, thereby enhancing environmental sustainability.

The results also show that circular economy adoption significantly improves firms' contributions to SDGs by promoting resource efficiency, waste reduction, and improved environmental performance. This is particularly important in the Nigerian oil and gas sector, where sustainability challenges and regulatory pressures continue to intensify.

Furthermore, the mediation analysis revealed that circular economy adoption plays a significant mediating role in the relationship between reverse logistics capability and SDG contribution. This suggests that reverse logistics capability contributes more effectively to sustainability outcomes when integrated into broader circular economy practices. Although the direct effect of reverse logistics capability on SDG contribution was marginally significant, its indirect effect through circular economy adoption was stronger, highlighting the importance of aligning operational capabilities with circular sustainability strategies.

Overall, the study contributes to theory by supporting the Resource-Based View, which emphasizes the role of firm capabilities in achieving sustainability outcomes. It also provides important empirical evidence from Nigeria's oil and gas sector, demonstrating that reverse logistics capability and circular economy adoption are key mechanisms for improving sustainability performance and advancing SDG achievement.

Limitations of the Study

1. **Sample Size and Scope**: The study focuses on 10 purposively sampled firms in Rivers State, which limits the generalizability of findings to the entire Nigerian oil and gas sector or other developing economies.
2. **Cross-Sectional Design**: The research design captures data at a single point in time, preventing causal inferences regarding the relationships among reverse logistics, circular economy adoption, and SDG contributions.
3. **Self-Reported Data**: The reliance on manager-reported questionnaire may introduce response bias, as perceptions of reverse logistics capability and SDG contributions might differ from actual operational performance.
4. **Sector Focus**: The study examines only the oil and gas industry, leaving the applicability of findings to other industrial sectors unexplored.

Future research could expand the sample size, adopt longitudinal designs, include additional industrial sectors, and incorporate objective performance metrics to strengthen external validity and causal understanding. By addressing these areas, future research can deepen understanding of how firm-level operational capabilities translate into tangible sustainability outcomes, thereby strengthening both theoretical models and practical guidance for industry and policy development.

Recommendations

For Industry Managers

- Institutionalize reverse logistics systems and integrate them into corporate strategy to maximize resource recovery and operational efficiency.
- Develop circular economy initiatives such as remanufacturing, industrial symbiosis, and closed-loop production to enhance sustainability performance and SDG contributions.
- Train personnel in sustainability practices to ensure effective implementation and monitoring of reverse logistics and circular economy programs.

For Policymakers and Regulatory Authorities:

- Provide incentives, subsidies, or regulatory frameworks that encourage investment in reverse logistics infrastructure and circular economy initiatives.
- Promote standards for environmental performance and resource recovery in the oil and gas sector to facilitate compliance and continuous improvement.

- Support public–private partnerships that enable knowledge sharing and technological innovation in waste-to-value and recycling programs.

For Academic Research and Policy Development:

- Encourage empirical studies that link firm-level operational practices with SDG outcomes in other industries and regions.
- Explore the interplay between technological, financial, and institutional factors in promoting circular economy adoption in emerging economies.

By adopting these strategies, oil and gas firms in Rivers State and similar developing economy contexts can enhance sustainability outcomes, operational resilience, and alignment with global development goals.

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