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CIRCULAR SUPPLY CHAIN MANAGEMENT AND PERFORMANCE OF CHEMICAL AND ALLIED MANUFACTURING FIRMS IN NAIROBI CITY COUNTY, KENYA

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ABSTRACT: *The study examined the influence of selected circular supply chain management practices on the performance of chemical and allied manufacturing firms in Nairobi City County, Kenya. Specifically, the study focused on reverse logistics, sustainable sourcing, and material resource optimisation and how these practices affect firm performance in terms of operational efficiency, cost reduction, environmental compliance, and competitiveness. Chemical and allied manufacturing firms in Nairobi City County operate in an environment characterised by high production costs, stringent environmental regulations, increasing waste management challenges, and growing stakeholder pressure for sustainability. Despite the strategic relevance of circular supply chain practices, many firms continue to rely on linear supply chain models, resulting in inefficiencies, resource wastage, and suboptimal performance. Empirical evidence on how specific circular supply chain practices influence firm performance in the sector remains limited, necessitating this study. The study adopted a descriptive research design targeting 188 chemical and allied manufacturing firms registered in Nairobi City County. A census approach was employed, with data collected from senior managers responsible for supply chain, operations, and procurement functions using structured questionnaires. The instruments were tested for validity and reliability. Data were analysed using descriptive statistics and inferential techniques, including correlation and multiple regression analysis. The findings revealed that reverse logistics, sustainable sourcing, and material resource optimisation each had a statistically significant and positive influence on firm performance. The study concludes that circular supply chain management practices are critical strategic drivers of performance in the chemical and allied manufacturing sector. The study recommends that firms strengthen reverse logistics systems, institutionalise sustainable sourcing policies, and invest in material resource optimisation technologies to enhance operational performance and long-term sustainability.*

KEYWORDS: Circular supply chain management, performance, reverse logistics, sustainable sourcing, material resource optimisation.

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INTRODUCTION

Circular supply chain management has increasingly become a central concern for manufacturing firms as sustainability and performance pressures intensify across global supply networks. In the chemical and allied manufacturing sector, the adoption of circular approaches is particularly critical due to the industry's high consumption of raw materials, energy intensity, and potential environmental risks (Bressanelli, Perona, & Saccani, 2018). Circular supply chain management emphasises closed-loop systems that promote efficient resource use, waste reduction, and value recovery, thereby enhancing both economic and environmental outcomes (Chen, Das & Ivanov, 2019). As governments, consumers, and investors demand greater accountability, firms are compelled to move away from linear production models toward more sustainable and resilient supply chain configurations.

Globally, the chemical manufacturing industry has witnessed a gradual but consistent shift toward circular practices as a response to resource scarcity, regulatory requirements, and competitive pressures. In countries such as India and China, rapid industrialisation and environmental degradation have prompted governments to promote circular economy principles through policy frameworks and regulatory incentives (Pandian & Abdul Kader, 2017; Niu, Xie, Mu, & Ji, 2020). Large chemical firms have increasingly integrated circular supply chain practices to improve operational efficiency, manage waste streams, and reduce production costs, thereby strengthening firm performance and regulatory compliance (Zhang, Venkatesh, Wang, Mani, Wan, & Qu, 2023). Similarly, in technologically advanced economies such as South Korea, strong institutional support and innovation have accelerated the adoption of circular supply chain management within chemical and allied industries, contributing to improved sustainability and competitiveness (Kim, Na, & Kim, 2021).

Within the African context, the adoption of circular supply chain management remains uneven but is gaining momentum as environmental challenges and regulatory pressures intensify. Countries such as Ghana and South Africa have initiated policy and institutional reforms aimed at promoting cleaner production, waste reduction, and resource efficiency in manufacturing (Reddy et al., 2019; Ohiomah, 2020). These initiatives highlight the growing recognition that circular supply chain practices can enhance firm performance by reducing operational costs, improving compliance, and strengthening supply chain resilience in resource-constrained environments (Baah et al., 2021).

In Kenya, and particularly in Nairobi City County, chemical and allied manufacturing firms operate within a complex environment characterised by rapid urbanisation, increasing waste management challenges, and rising sustainability expectations from regulators and stakeholders (Nyakundi, 2017). Government policies such as the Green Economy Strategy and Implementation Plan and regulatory oversight by the National Environment Management Authority have reinforced the need for sustainable production and responsible supply chain practices (MEFK, 2021; NEMA, 2023). At the same time, firms face persistent challenges related to high production costs, inefficient resource utilization, and supply chain disruptions, which continue to undermine performance in the sector.

Firm performance in the chemical and allied manufacturing industry is typically assessed using a combination of operational, financial, environmental, and resilience-related indicators. Prior studies suggest that the adoption of circular supply chain management practices contributes to improved efficiency, cost reduction, enhanced compliance, and stronger stakeholder

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relationships, all of which are essential for long-term competitiveness (Kusi Sarpong et al., 2023; Zhang, Wang, Farooque, Wang, & Choi, 2021). Despite these potential benefits, empirical evidence on the influence of circular supply chain management on the performance of chemical and allied manufacturing firms in Nairobi City County remains limited. This gap underscores the need for context-specific studies that examine how circular supply chain practices affect firm performance within Kenya's manufacturing sector**.**

Statement of the problem

The chemical and allied manufacturing industry is a critical pillar of Kenya's industrial and economic development, making a substantial contribution to gross domestic product and employment. According to the Kenya National Bureau of Statistics (KNBS, 2021), the sector accounted for 12.7 percent of total manufacturing output in 2020, with a valuation exceeding KES 250 billion. Despite this significance, firms within the industry, particularly those operating in Nairobi City County, face persistent sustainability and performance challenges. The sector is a major source of industrial waste and pollution, with reports indicating the discharge of hazardous substances such as heavy metals and volatile organic compounds into the environment, posing serious risks to public health and ecosystems (NEMA, 2019). In addition, high energy consumption and dependence on nonrenewable resources have resulted in a substantial environmental footprint, with the industry contributing significantly to industrial carbon emissions in Kenya (UNEP, 2020).

Beyond environmental concerns, chemical and allied manufacturing firms continue to experience operational inefficiencies driven by traditional linear supply chain models characterized by excessive material and energy losses. Estimates suggest that up to 30 percent of raw materials are wasted during production processes, leading to increased operational costs and reduced competitiveness (KAM, 2022). Although circular supply chain management has been widely promoted as a viable approach for addressing waste, inefficiency, and environmental degradation, its application within the chemical and allied manufacturing sector in Nairobi City County remains inadequately explored. Existing empirical studies on circular supply chain management in Kenya have largely focused on other manufacturing sectors, leaving limited evidence on its influence on the performance of chemical and allied firms (Omar, 2020; Kinoti & Barasa, 2022; Kamanga, 2024; Nyambura, 2021). This lack of sector-specific and context-based empirical evidence constrains informed decision-making and underscores the need for focused research on circular supply chain management and firm performance in Nairobi City County.

RESEARCH OBJECTIVES

i. To determine the influence of reverse logistics on the performance of chemical and allied manufacturing firms in Nairobi City County.

ii. To examine the influence of sustainable sourcing on the performance of chemical and allied manufacturing firms in Nairobi City County.

iii. To find out the influence of material resource optimisation on the performance of chemical and allied manufacturing firms in Nairobi City County.

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THEORETICAL REVIEW

Theoretical perspectives provide a critical foundation for understanding how circular supply chain management practices influence firm performance in manufacturing contexts. One of the most influential frameworks in strategic management is the Resource-Based View, which emphasises that firm performance is largely determined by the effective deployment of internal resources and capabilities. Introduced by Barney in 1991, the theory argues that organisations achieve sustained competitive advantage when they possess resources that are valuable, rare, difficult to imitate, and non-substitutable. Within manufacturing environments, operational systems, process know-how, managerial expertise, and organisational routines constitute strategic resources that can enhance efficiency and performance. From this perspective, circular supply chain management practices represent firm-specific capabilities that enable manufacturers to reduce costs, improve efficiency, and respond effectively to regulatory and market pressures, thereby strengthening their competitive position.

The Resource-Based View further suggests that firms that successfully integrate sustainability-orientated practices into their internal operations are better positioned to create long-term value. In industries such as chemical and allied manufacturing, where compliance costs, waste management, and resource intensity are high, the ability to internalise and manage circular processes can differentiate firms from competitors. By embedding circular practices within operational routines and decision-making processes, firms transform sustainability initiatives into strategic assets that contribute to superior performance rather than viewing them as compliance-driven costs (Barney, 1991; Vachon & Klassen, 2006). This theoretical lens therefore supports the argument that internal capabilities associated with circular supply chain management can directly influence firm performance outcomes.

Stakeholder theory offers a complementary perspective by emphasising the importance of aligning organisational activities with the expectations of key stakeholder groups. Proposed by Freeman in 1984, the theory contends that firms must balance the interests of multiple stakeholders, including customers, suppliers, employees, regulators, and communities, in order to achieve sustainable performance. In the contemporary manufacturing environment, stakeholders increasingly demand environmentally responsible and socially ethical business practices. Firms that fail to respond to these expectations risk reputational damage, regulatory sanctions, and loss of market share. Stakeholder theory thus provides a rationale for why firms adopt circular supply chain practices as a means of enhancing legitimacy, trust, and long-term relationships with critical stakeholders (Freeman, 1984; Elkington, 1997).

The Theory of Constraints further enriches the theoretical foundation by focusing on operational efficiency and performance improvement. Introduced by Goldratt in 1984, the theory posits that organisational performance is limited by a small number of critical constraints or bottlenecks within systems and processes. Improving overall performance therefore requires identifying and systematically addressing these constraints. In manufacturing settings, inefficiencies related to resource utilisation, waste handling, and process flow often act as major constraints that limit productivity and profitability. Applying the Theory of Constraints highlights the importance of process optimisation and continuous improvement in enhancing firm performance (Goldratt, 1984; Cagno et al., 2017).

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EMPIRICAL REVIEW

Mishra et al. (2023) conducted a comprehensive systematic literature review to explore reverse logistics and closed-loop supply chains across various industries, including chemical manufacturing. Their analysis of 382 papers using content analysis revealed that reverse logistics contributed to firm performance by reducing costs, enhancing customer satisfaction, and improving environmental performance. The study pointed out a significant research gap, emphasising the need for more empirical studies specifically within the chemical industry context to validate these findings.

Karagoz et al. (2022) researched the design of a stochastic reverse logistics network for waste of electrical and electronic equipment in Turkey using a stochastic programming model. The target population included electronics manufacturing firms, and data were analysed using mixed integer linear programming. The findings indicated that reverse logistics implementation resulted in substantial cost savings and improved environmental performance. However, the study's limitation to electronics manufacturing suggests the need for similar models to be tested in the chemical manufacturing sector.

Nag and Ferdausy (2021) investigated the role of information technology and collaboration in reverse logistics supply chains in the United States through a survey-based empirical study using structural equation modelling. They found that IT and collaboration in reverse logistics positively impacted firm performance by enhancing efficiency and coordination. However, considering the study was conducted in 2008, there is a need for updated research reflecting recent technological advancements in the chemical industry.

Sánchez-Flores et al. (2020) carried out a study to determine the sustainable supply chain management in emerging economies: Trade-offs between environmental and cost performance in China. Utilising a survey-based empirical design targeting manufacturing firms, the study employed structural equation modelling for data analysis. The findings revealed that while sustainable sourcing improved environmental performance, it had a short-term negative impact on cost performance. This underscores the need for further exploration into the long-term financial implications of sustainable sourcing within the chemical sector.

Darbari et al. (2018) conducted a study on the "Implementation of interpretive structural modelling methodology as a tool for sustainable supply chain management" in India. They employed the Interpretive Structural Modeling (ISM) methodology, targeting manufacturing experts. The study identified sustainable sourcing as a crucial driver for sustainable supply chain management, indirectly enhancing firm performance. However, the research was theoretical, indicating a need for empirical validation in the chemical industry context.

Wongthongchai and Saenchaiyathon (2019) explored "Institutional-based antecedents and performance outcomes of internal and external green supply chain management practices" in China. The researchers conducted a survey-based empirical study targeting manufacturing firms, with data analysed using structural equation modelling. Their findings demonstrated that sustainable sourcing practices, driven by institutional pressures, positively influenced both environmental and economic performance. The study's broad scope suggests a need for focused research on the specific regulatory impacts within the chemical industry.

Shao, Yu, and Feng (2019) investigated material resource optimisation and environmental performance in Chinese chemical industries. Using a quantitative research design with a sample

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of 80 firms, they applied structural equation modelling (SEM) to demonstrate that high material resource optimisation improves environmental performance and compliance with regulations. Additionally, it positively impacts financial performance by reducing waste-related costs. The study's primary focus on environmental benefits leaves a gap in understanding the direct financial impacts of resource efficiency.

Tran and Vo (2020) examined the impact of resource efficiency on financial performance in allied manufacturing firms in the UK. Their cross-sectional study, involving 60 firms, used ordinary least squares (OLS) regression to find that improved resource efficiency is linked to higher profitability and better financial performance. Efficient material usage reduces costs and enhances competitive advantage. The study, however, is limited to allied manufacturing and does not account for variations across different chemical sectors.

İncekara (2022) performed a longitudinal study on the impact of resource efficiency on environmental and economic performance in Swedish chemical manufacturing firms. Analysing data from 70 firms using longitudinal data analysis and econometric modelling, they found that resource efficiency leads to sustained improvements in both environmental and economic performance. The study highlights long-term benefits and cost savings. Nonetheless, it may not capture immediate effects and could benefit from a more varied industry context.

Thanki and Thakkar (2020) investigated the influence of material efficiency on operational and financial performance in Indian chemical industries through a quantitative research design involving 55 firms. Regression and correlation analyses revealed that material efficiency positively affects operational efficiency and financial performance, with significant cost savings and productivity improvements. The study, however, lacks a detailed exploration of the specific mechanisms behind efficiency improvements and would benefit from a more sector-specific analysis.

Despite extensive empirical work on circular supply chain management practices, several research gaps remain evident when the existing studies are considered collectively. Much of the empirical evidence on reverse logistics has been generated outside the chemical manufacturing context, with studies either adopting cross-industry reviews or focusing on sectors such as electronics and allied manufacturing, thereby limiting sector-specific generalisability (Mishra et al., 2023; Karagoz et al., 2022). Additionally, earlier studies examining the role of information technology and collaboration in reverse logistics rely on dated data that may not reflect recent technological advancements affecting chemical supply chains (Nag & Ferdausy, 2021). Empirical findings on sustainable sourcing present mixed performance outcomes, with some studies reporting short-term cost trade-offs and others offering largely theoretical insights, underscoring the need for context-specific and performance-focused validation within chemical manufacturing (Sánchez Flores et al., 2020; Darbari et al., 2018). Similarly, studies on material resource optimisation are geographically concentrated in developed and Asian economies, often emphasising environmental outcomes over comprehensive firm performance measures, creating a gap in emerging economy contexts such as Nairobi City County (Shao et al., 2019; İncekara, 2022).

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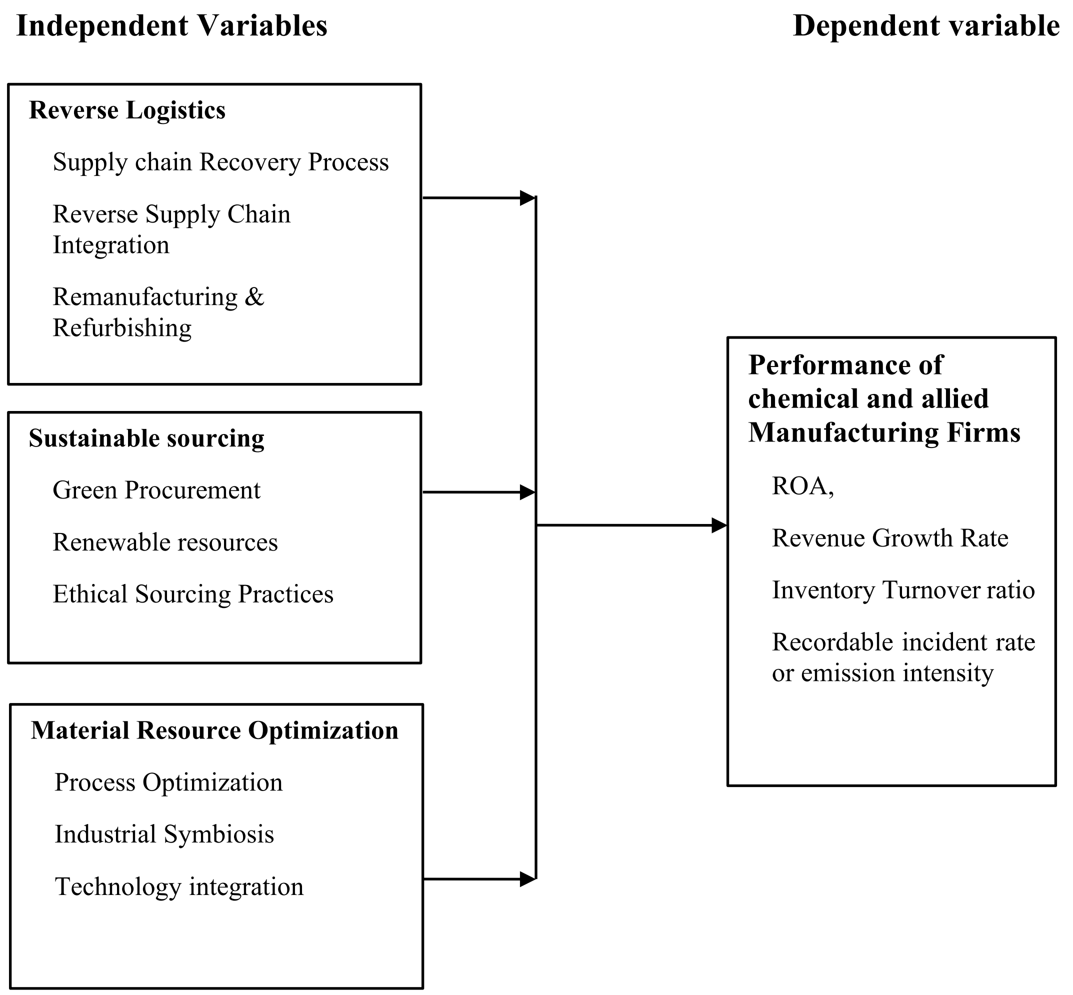
Conceptual Framework

The summary of the conceptual framework is presented in Figure 1

Figure 1: Conceptual Framework



RESEARCH METHODOLOGY

The study adopted a structured methodological approach to examine the influence of circular supply chain management on the performance of chemical and allied manufacturing firms in Nairobi City County. A descriptive research design was employed to allow for systematic collection and analysis of quantitative data without manipulating the study variables. This design was considered appropriate, as it facilitates the examination of existing conditions and relationships among circular supply chain practices and firm performance, providing a comprehensive understanding of prevailing patterns within the sector. The approach enabled the researcher to capture current practices and performance outcomes as perceived by key managerial personnel within the firms.

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The target population comprised all chemical and allied manufacturing firms operating in Nairobi City County. According to records from the Kenya Association of Manufacturers, there were 80 registered firms at the time of the study. Each firm contributed respondents from four functional areas considered critical to circular supply chain management and performance evaluation, namely supply chain management, operations, environmental and sustainability management, and finance. This resulted in a total population of 320 potential respondents. The sampling frame therefore included all 80 firms and the identified functional managers, ensuring comprehensive sector coverage and minimising sampling bias.

To determine an appropriate sample size, the Yamane formula was applied to the population of 320 respondents, yielding a sample of 176 participants at a 5 per cent margin of error. Purposive sampling was initially used to identify respondents with relevant expertise and decision-making responsibility in circular supply chain-related activities. Thereafter, simple random sampling was applied to select the final respondents from each functional category, ensuring representativeness and enhancing the generalisability of the findings. The final sample included equal representation from each managerial role, with safeguards to ensure that no firm contributed more than one respondent per functional area or more than three respondents overall.

Data were collected using a semi-structured questionnaire designed to capture information on circular supply chain practices and firm performance. The questionnaire comprised closed-ended items measured on a five-point Likert scale to facilitate quantitative analysis, alongside a limited number of open-ended questions to provide contextual clarification where necessary. Questionnaires were self-administered and distributed through a combination of electronic mail and physical visits to the firms. Data collection was supported by trained research assistants, and follow-up procedures, including reminder emails and phone calls, were implemented to enhance response rates. Relevant research permits and institutional approvals were obtained prior to data collection to ensure ethical compliance and access to participating organisations.

A pilot study involving approximately 10 per cent of the sample size was conducted to test the clarity, validity, and reliability of the research instrument. Feedback from the pilot informed revisions to the questionnaire to address ambiguities and improve alignment with the study objectives. Validity was established through multiple approaches, including content validity assessed by subject matter experts, construct validity confirmed through factor analysis, criterion validity through correlation with established measures, and face validity through expert review. Reliability was evaluated using Cronbach's alpha, with all scales exceeding the acceptable threshold, indicating strong internal consistency.

Data analysis involved both descriptive and inferential statistical techniques. Descriptive statistics were used to summarise respondent characteristics and key study variables, while inferential analysis employed correlation and multiple regression techniques to examine the relationships between circular supply chain management practices and firm performance. The regression model enabled assessment of the magnitude and direction of influence of the independent variables on performance outcomes.

The model took the following form:

$$Y = \beta 0 + \beta 1X1 + \beta 2X2 + \beta 3X3 + \epsilon$$

Where: Y = Performance of Chemical and Allied Manufacturing Firms

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B_0= Constant

a = Constant

X_1: Reverse Logistics, **X_2:** Sustainable sourcing, **X_3:** Material Resource Optimisation

ϵ is the error term

β_1, β_2, and β_3= Coefficient of Independent variables

RESULTS AND ANALYSIS

Response rate

A total of 176 questionnaires were administered to selected respondents. Out of these, 152 were correctly completed and returned, resulting in a response rate of 86.36%, as shown in Table 1. This high rate suggests strong engagement and reliability of the data collected. According to Baruch and Holtom (2008), a response rate of 80% or higher is generally considered excellent in organisational research.

Table 1: Response Rate

Category	Frequency	Percent
Response	152	86.36
Non-response	24	13.64
Total	**176**	**100**

Descriptive findings

The descriptive findings are summarized in table 2 below;

Table 2: Summary of Descriptive Findings

Variable	Statement	Mean	Std. Dev
Reverse Logistics	Implementation of reverse logistics has significantly reduced waste disposal costs	4.41	0.635
Reverse Logistics	Efficient recovery of materials has contributed to lower production costs	4.49	0.630
Reverse Logistics	Consolidated reverse shipments have enhanced transportation efficiency	4.34	0.892
Reverse Logistics	Reverse logistics has improved operational sustainability	4.05	1.066
Reverse Logistics	Integration of reverse logistics with production processes has optimized resource use	4.05	1.082
Sustainable Sourcing	Green procurement practices have reduced operational costs	4.26	0.980

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Sustainable Sourcing	Sourcing renewable resources has reduced environmental impact	4.28	1.123
Sustainable Sourcing	Ethical sourcing has improved the firm's reputation.	4.28	0.957
Sustainable Sourcing	Sustainable sourcing has enhanced supply chain resilience	4.41	0.857
Sustainable Sourcing	Supplier sustainability assessments improve material quality	4.32	1.033
Material Resource Optimisation	Use of renewable energy has led to cost savings	4.32	0.918
Material Resource Optimisation	Investment in resource-efficient technologies provides competitive advantage	4.05	1.178
Material Resource Optimisation	Waste minimization strategies have improved operational efficiency	4.05	1.150
Material Resource Optimisation	By-product utilization has created additional revenue streams	4.18	1.198
Material Resource Optimisation	Process optimisation has reduced resource use and enhanced efficiency	4.26	1.040

As shown in the table, the descriptive findings indicate a high level of agreement among respondents regarding the adoption of circular supply chain management practices within chemical and allied manufacturing firms in Nairobi City County. Reverse logistics recorded strong mean scores, particularly in reducing waste disposal and production costs, indicating its effectiveness in enhancing operational efficiency and sustainability. Sustainable sourcing practices similarly demonstrated high mean values, suggesting that green procurement, ethical sourcing, and supplier sustainability assessments contribute positively to cost reduction, supply chain resilience, and firm reputation. Material resource optimisation also registered consistently high mean scores, reflecting the role of renewable energy use, waste process optimisation, and byproduct utilisation in improving efficiency and generating additional value. Overall, the relatively low standard deviations across the variables suggest a strong consensus among respondents on the positive influence of these practices. These findings imply that circular supply chain management practices are well established and perceived as critical drivers of performance in the chemical and allied manufacturing sector.

Correlation Analysis

Correlation analysis is a statistical method used to measure the strength and direction of the linear relationship between two continuous variables (Cohen et al., 2013). It helps researchers understand how changes in one variable may be associated with changes in another. In this study, Pearson's correlation coefficient was employed to assess the degree of association between the independent variables—reverse logistics, sustainable sourcing, eco-design practices, and material resource optimisation—and the dependent variable, firm performance, as shown in table 3 below

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Table 3: Correlation Analysis

		Reverse logistics	sustainable sourcing	Material resource Optimisation	Performance
Reverse logistics	Pearson Correlation	1			
	Sig. (2-tailed)				
	N	152			
Sustainable sourcing	Pearson Correlation	.367**	1		
	Sig. (2-tailed)	.000			
	N	152	152		
Material resource Optimisation	Pearson Correlation	.325**	.378**	1	
	Sig. (2-tailed)	.000	.000		
	N	152	152	152	
Performance	Pearson Correlation	.667**	.661**	.683**	1
	Sig. (2-tailed)	.000	.000	.000	
	N	152	152	152	152

The correlation analysis revealed statistically significant and positive relationships between the selected circular supply chain management practices and the performance of chemical and allied manufacturing firms in Nairobi City County. As indicated in the correlation matrix, reverse logistics exhibited a strong positive association with firm performance ($r = .667$, $p < .005$), suggesting that effective implementation of activities such as recycling, remanufacturing, and consolidated reverse flows enhances cost efficiency, regulatory compliance, and overall operational effectiveness. Sustainable sourcing also demonstrated a strong positive correlation with performance ($r = .661$, $p < .005$), implying that environmentally and ethically responsible sourcing practices contribute to improved firm outcomes through enhanced efficiency, stakeholder trust, and supply stability. Material resource optimisation recorded the strongest correlation with performance ($r = .683$, $p < .005$), highlighting the critical role of efficient material and energy use, waste reduction, and process optimisation in driving superior performance.

Regression Analysis

Regression Analysis

Regression analysis is a fundamental statistical technique used to explore and quantify the relationship between one dependent variable and multiple independent variables. It allows researchers to determine the extent to which independent variables can predict or explain variations in the dependent variable (Field, 2013). In this study, first regression analysis was done per independent variable before conducting a multiple linear regression model.

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Regression analysis for Reverse Logistics

A simple linear regression analysis was conducted between reverse logistics (independent variable) and firm performance (dependent variable). The model summary, as shown in table 4, shows an R-value of 0.667 and an R-square of 0.445, indicating that 44.5% of the variation in firm performance is explained by reverse logistics. The adjusted R-square of 0.440 confirms the model's stability, while the standard error of 2.94852 suggests a relatively good fit.

Table 4: Model Summary for Reverse Logistics

Model	**R**	**R Square**	**Adjusted R**	**Std. Error of the Estimate**
1	.667[a]	.445	.440	2.94852
a. Predictors: (Constant), Reverse Logistics				

The ANOVA results in table 5 below show an F-value of 120.267 with a p-value of .000, confirming that the model is statistically significant. Therefore, the relationship between reverse logistics and performance is not due to random chance.

Table 5: ANOVA for Reverse Logistics

Model		**Sum of Squares**	**Df**	**Mean Square**	**F**	**Sig.**
1	Regression	810.225	1	810.225	120.267	.000[b]
	Residual	1010.275	150	6.735		
	Total	1820.500	151			
a. Dependent Variable: Firm performance						
b. Predictors: (Constant), Reverse Logistics						

The regression coefficients in Table 6 show that the unstandardised coefficient for reverse logistics is 0.452, with a standardised beta of 0.303, a t-value of 3.896, and a p-value less than 0.05. This confirms that reverse logistics has a statistically significant and positive influence on firm performance. For every unit increase in reverse logistics, performance improves by 0.452 units, holding other factors constant.

Table 6: Regression Coefficient for Reverse Logistics

Model		Unstandardized Coefficients		Standardized Coefficients	T	Sig.
		B	Std. Error	Beta		
1	(Constant)	29.285	5.491		5.333	.000
	Reverse Logistics	.452	.116	.303	3.896	.000
a. Dependent Variable: Firm Performance						

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Regression analysis for Sustainable Sourcing

Simple linear regression was also carried out between sustainable sourcing and firm performance. The model yielded an R-value of 0.661 and an R-square of 0.437, indicating that sustainable sourcing explains 43.7% of the variation in firm performance. The adjusted R-squared of 0.432 supports the model's reliability, with a standard error of 2.97581.

Table 7: Model Summary for Sustainable Sourcing

Model	R	R Square	Adjusted R-Square	Std. Error of the Estimate
1	.661[a]	.437	.432	2.97581
a. Predictors: (Constant), Sustainable Sourcing				

The ANOVA output produced an F-statistic of 116.303 with a significance level of .000, indicating a statistically significant relationship. Therefore, the relationship between the sustainable sourcing and performance is highly unlikely to be due to chance.

Table 8: ANOVA for for Sustainable Sourcing

Model		Sum of Squares	Df	Mean Square	F	Sig.
1	Regression	795.049	1	795.049	116.303	.000[b]
	Residual	1025.451	150	6.836		
	Total	1820.500	151			
a. Dependent Variable: Firm performance						
b. Predictors: (Constant), Sustainable sourcing						

Regression coefficients revealed that sustainable sourcing has an unstandardised coefficient of 0.449 and a standardised beta of 0.344. The t-value was 4.486, with a p-value of .000. These results confirm that sustainable sourcing has a significant and positive impact on performance. An increase in sustainable sourcing practices by one unit is associated with a 0.449-unit increase in performance.

Table 9: Regression Coefficients for Sustainable Sourcing

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	27.499	5.171		5.318	.000
	Sustainable Sourcing	.449	.100	.344	4.486	.000
a. Dependent Variable: Firm performance						

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Regression analysis for Material Resource Optimisation

Another simple regression analysis was conducted to examine the effect of material resource optimisation on firm performance. The results are summarised in Table 10, where the model recorded an R-value of 0.683 and an R-squared of 0.467. This implies that 46.7% of the variation in firm performance is explained by material resource optimisation. The adjusted R-squared was 0.462, and the standard error of the estimate was 2.86714, indicating a strong model fit.

Table 10: Model Summary for Material Resource Optimisation

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.683[a]	.467	.462	2.86714
a. Predictors: (Constant), Material Resource Optimization				

The ANOVA results in Table 11 show an F-value of 131.473 and a significance level of .000, demonstrating that the model is statistically significant and that the relationship between material resource optimisation and performance is not due to chance.

Table 11: ANOVA for Material Resource Optimization

Model		Sum of Squares	Df	Mean Square	F	Sig.
1	Regression	850.365	1	850.365	131.473	.000[b]
	Residual	970.135	150	6.468		
	Total	1820.500	151			
a. Dependent Variable: Firm performance						
b. Predictors: (Constant), Material Resource Optimization						

The regression coefficients presented in Table 12 show that material resource optimisation had the highest unstandardised coefficient among all the variables at 0.719, with a standardised beta of 0.479. The t-value was 6.692, and the p-value was less than 0.05. These results confirm that material resource optimisation has a strong, positive, and statistically significant effect on firm performance

Table 12: Regression coefficient for material resource optimisation

Model		Unstandardized Coefficients		Standardized Coefficients	T	Sig.
		B	Std. Error	Beta		
1	(Constant)	13.696	5.534		2.475	.000
	Material Resource Optimisation	.719	.107	.479	6.692	.000
a. Dependent Variable: Firm Performance						

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Multiple-Linear Regression

The multiple linear regression results presented in Tables 13, 14 and 15 provide a comprehensive assessment of the combined influence of reverse logistics, sustainable sourcing, and material resource optimisation on the performance of chemical and allied manufacturing firms in Nairobi City County.

Table 13: Model summary

Model	R	R Square	Adjusted R-Square	Std. Error of the Estimate
1	.781	.610	.602	2.21487

a. Predictors: (Constant), Reverse Logistics, Sustainable Sourcing, Material Resource Optimization

As indicated in Table 12, the model summary demonstrates a strong positive relationship between the three independent variables and firm performance, with an R value of 0.781. The R-squared value of 0.610 shows that 61.0 per cent of the variation in firm performance is jointly explained by reverse logistics, sustainable sourcing, and material resource optimisation.

Table 14: ANOVA

Model	Sum of Squares	df	Mean Square	F	Sig.
Regression	1110.382	3	370.127	75.436	.000
Residual	710.118	148	4.798		
Total	1820.500	151			

a. Dependent Variable: Firm Performance
b. Predictors: (Constant), Reverse Logistics, Sustainable Sourcing, Material Resource Optimisation

The overall statistical significance of the regression model is confirmed by the ANOVA results in Table 4.15. The F statistic of 75.436 with a corresponding p value of .000 indicates that the regression model is statistically significant at the 5 per cent level. This finding implies that the combined effect of reverse logistics, sustainable sourcing, and material resource optimisation on firm performance is not due to random variation.

Table 15: Regression coefficients

Model	Unstandardized Coefficients (B)	Std. Error	Standardized Coefficients (Beta)	t	Sig.
(Constant)	1.216	1.842		.660	.010
Reverse Logistics	.412	.055	.558	7.491	.000
Sustainable Sourcing	.305	.052	.182	5.865	.000
Material Resource Optimisation	.468	.057	.536	8.211	.000

The individual contribution of each predictor variable is detailed in Table 15, which reports the unstandardised and standardised regression coefficients. Reverse logistics recorded a positive and statistically significant coefficient (B = 0.412, $p < .001$), indicating that an improvement

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in reverse logistics practices leads to a corresponding increase in firm performance when other factors are held constant. The standardised beta value of 0.558 highlights reverse logistics as one of the strongest predictors in the model. Sustainable sourcing also exhibited a positive and significant effect on performance ($B = 0.305$, $p < .001$), though with a comparatively moderate standardised beta of 0.182. This suggests that environmentally and ethically responsible sourcing practices contribute meaningfully to firm performance. Material resource optimisation emerged as the strongest predictor, with a coefficient of 0.468 and a standardised beta of 0.536, indicating that efficient use of materials and resources has a substantial and positive influence on firm performance. Overall, the regression results confirm that all three circular supply chain management practices significantly and positively affect firm performance.

CONCLUSIONS

Based on the findings of the study, several conclusions are drawn in line with the specific objectives addressing circular supply chain management practices and the performance of chemical and allied manufacturing firms in Nairobi City County. The first objective sought to determine the influence of reverse logistics on firm performance. The study concludes that reverse logistics has a strong, positive, and statistically significant effect on performance. Practices such as recycling, remanufacturing, reuse of materials, and effective management of returned products contribute substantially to cost reduction, improved resource recovery, and enhanced compliance with environmental regulations. These outcomes translate into improved operational efficiency and overall firm performance. The findings affirm that reverse logistics extends beyond waste handling and should be viewed as a strategic capability that supports competitiveness and sustainability in the manufacturing sector.

The second objective examined the influence of sustainable sourcing on firm performance. The study concludes that sustainable sourcing practices positively and significantly affect performance, although the magnitude of influence is moderate compared to the other practices examined. Firms that integrate environmental and ethical considerations into procurement decisions benefit from improved supplier reliability, enhanced regulatory compliance, reduced supply chain risks, and strengthened corporate reputation. These benefits contribute to greater supply chain resilience and stable operational outcomes. The results underscore that sustainable sourcing is an important component of circular supply chain management, particularly in environments characterised by increasing regulatory scrutiny and stakeholder expectations.

The third objective focused on determining the influence of material resource optimisation on firm performance. The study concludes that material resource optimisation exerts the strongest positive influence on performance among the examined practices. Efficient utilisation of raw materials, adoption of energy-saving technologies, waste minimisation, and process optimisation significantly enhance productivity, reduce operational costs, and improve environmental performance. Firms that prioritise resource efficiency are better positioned to achieve both financial sustainability and environmental responsibility.

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RECOMMENDATIONS

Based on the findings of the study, several practical and policy-orientated recommendations are proposed to enhance the adoption of circular supply chain management practices and improve firm performance among chemical and allied manufacturing firms in Nairobi City County. Given the strong and significant influence of reverse logistics on performance, firms should institutionalise structured reverse logistics systems supported by clear policies and standard operating procedures. These systems should address product returns, recycling, remanufacturing, and safe disposal of waste materials. Investment in digital tracking tools and information systems is recommended to improve visibility and coordination of reverse flows. In addition, firms should train employees and collaborate with specialised third-party logistics providers to improve efficiency. Regulatory agencies should support these efforts through clear guidelines and incentives that encourage investment in reverse logistics infrastructure.

With regard to sustainable sourcing, firms are advised to integrate sustainability criteria into procurement policies and supplier evaluation processes. This includes prioritizing suppliers who comply with environmental regulations, ethical labour standards, and responsible resource use. Regular supplier audits and the adoption of supplier codes of conduct aligned with recognised sustainability standards can enhance accountability and material quality. Firms should also pursue long-term partnerships with suppliers committed to sustainable practices, as this can strengthen supply chain resilience and reduce risks. Industry associations and policymakers should facilitate supplier development programmes and provide incentives that lower the cost of transitioning to sustainable sourcing, particularly for local and small-scale suppliers.

Material resource optimisation should be treated as a strategic priority, given its strong influence on firm performance. Firms are encouraged to adopt efficiency-driven frameworks such as lean manufacturing and continuous improvement systems to reduce material waste, energy consumption, and process inefficiencies. Investments in energy-efficient technologies, real-time monitoring systems, and data analytics can support informed decision-making and resource control. Establishing clear performance indicators for resource efficiency and conducting regular audits will help identify improvement opportunities. Policymakers should further promote industrial symbiosis initiatives and provide financial or technical support to firms investing in resource-efficient and cleaner production technologies.

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