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Circular Manufacturing Practices and Performance of
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Circular Manufacturing Practices and Performance of Manufacturing Companies in Kenya

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ABSTRACT

Purpose: This study evaluated the influence of circular manufacturing on the performance of manufacturing companies in Kenya.

Methodology: Employing a cross-sectional survey design, the study targeted 795 manufacturing companies in Kenya, excluding the service sector, as per the 2023 KAM directory. A sample of 266 companies was drawn using Slovin's formula and stratified sampling technique. Data was collected using questionnaires. Quantitative data was analyzed using both descriptive and inferential statistics and with the help of SPSS version 27. Regression analysis was used to show the relationship between the dependent variable and the independent variable and the study employed multiple linear regression analysis to test the hypotheses.

Findings: Key findings revealed that circular manufacturing had significant effects on company performance and supply chain reconfiguration demonstrated a significant moderating effect on the relationship between circular manufacturing and company performance. These findings indicated that circular manufacturing negatively influence the performance of manufacturing companies in Kenya.

Unique Contribution to Theory, Policy and Practice: The findings contribute to understanding circular economy principles in the Kenyan manufacturing context and provide valuable insights for practitioners and policymakers in implementing circular supply chain management practices by pointing out that circular manufacturing practices may lead to short time performance declines but adequate planning to address these challenges can enable companies to achieve long-term benefits.

Keywords: *Circular Manufacturing Practices, Supply Chain Practices, Manufacturing Companies, Kenya*

JEL Codes: *Q01, Q56, L23, L60, O14, M11*

1.1. Background of the Study

The circular economy concept has gained significance both in academia and practice in the recent years due to its numerous benefits which are attributed to an ever-increasing sensitivity towards product recovery. Factors such as extended producer responsibility (EPR), environmental sustainability requirements, brand image, economic benefits and increasing rate of returns fuel the need for circular economic practices (Choudhary, 2022).

In Kenya, the industrial set up has greatly evolved ever since independence. The latest developments in the millennium were adoption in the year 2000 of The Africa Growth and Opportunities Act which was to promote export of textiles from Africa to America, the Kenya industrial property institute in the year 2001 which was to grant and enforce property rights and trademarks. The Kenya Investment Authority was also set up in the year 2004 to introduce mandatory investment thresholds and restrictive screening procedures for foreign investments and eventually in year 2008, the Vision 2030 was created to make Kenya globally competitive and prosperous, and its economic pillar pays special attention to manufacturing and proposes important projects in support of the sector (Nguï et al., 2016).

According to The Vision 2030 Delivery Secretariat, Kenya has a national long- term development blueprint that intends to create a prosperous nation that is globally competitive. It aims to transform Kenya into a newly industrializing, middle- income country with high quality life for its citizens, a clean and secure environment by 2030 (Vision2030, 2019). One of the pillars of the vision is the economic pillar which aims to achieve an average economic growth rate of 10 per cent per annum and sustaining the same until 2030 through apart from other sectors, manufacturing (Vision2030, 2019). The role of the manufacturing sector in the vision 2030 is to create employment and wealth through strengthening the capacity and local content of domestically manufactured goods, increase generation and utilization of Research and Development results, raise the share of products in the regional market from 7 percent to 15 percent and lastly to develop niche products for existing and new markets.

There are some Kenyan companies which have adopted the circular economy policy as a means of enhancing performance in their organizations. This is mostly generalized under green processes though it is still rooted under the circular concept of a regenerative system in which resource input and waste, emission and energy leakage are minimized by slowing, closing and narrowing material and energy loops. Mumias Sugar before facing its financial challenges decided to respond to high energy prices in the country by embarking on an innovative green project. According to Rosebell (2017), using bagasse- a natural, industrial waste product in the industry, the company can produce biogas which powers their electricity generators. It uses only a third of the electricity it produces and sells the rest to the national grid which hence earns the company revenue as well as carbon credits (Rosebell, 2017).

Additionally, it is good to note that the effectiveness of circular activities remains on the ability of a product to be recycled back into its almost original purpose, but lack of adequate technology and invaluable market conditions are among the issues that are deterring us from achieving circular economy in Kenyan manufacturing companies (KAM, 2024). Regionally, apart from Rwanda which is a member of the African Circular Economy Alliance (ACEA), Kenya is at a forefront of championing sustainability where government and private sector are working to achieve circular economy through partnerships that seek to reduce plastic waste in the environment through collection and recycling (KAM, 2024) but more undocumented circular activities might be in operation hence this paper aims at defining a set of aspects that are currently being used by manufacturers in circular returns management practices and how they assist in meeting their performance goals.

1.2.Statement of the Problem

The manufacturing industry in Kenya has in the recent years faced significant challenges regarding sustainability and efficient resource utilization. As global markets and industries embrace sustainability, the need for more responsible production and consumption practices has become pressing, particularly concerning how manufacturing companies handle product returns in relation to the concept of circular economy principles (Musau, 2021).

Circular manufacturing practices have the potential to transform the manufacturing processes, reduce waste and enhance operational efficiency due to its focus on the recovery, recycling and reuse of products and materials in the supply chain. However, despite the promise of a circular economy many manufacturing companies in Kenya continue to struggle with ineffective systems which lead to increased waste, inefficient use of resources and higher costs (Mor et al., 2021).

Manufacturing plays a pivotal role in Kenya's economic development due to its significant contribution to industrial output, employment and export growth. Manufacturing GDP contribution can give indications whether a country is making strides in industrialization. Notwithstanding, the sector's performance over the last 10 years has faced significant challenges, which has seen its contribution to GDP drop significantly from 11.08% recorded in 2011 to 7.8% in 2022. Kenya hopes to reverse this trend through the Manufacturing 20BY30 Vision that seeks to increase the sector's contribution to GDP to 20% by 2030. However, it is good to note that in the recent years the world real GDP growth has slowed down to 2.4% in 2024 from 2.6% in 2023, 3.0% in 2022 and a high of 6.2% in 2021 while the Kenyan real GDP has experienced volatility with a high of 7.8% in 2021 dropping to 4.8% in 2022, staggering to 5.1% in 2023 and 5.3% in 2024 (KAM, 2024) and (KNBS, 2024). All this is affected by various circumstances such as management of the manufacturing process within the supply chain, particularly in the context of circular economy practices remains under explored in Kenya's manufacturing sector. It is also notable that in the Kenyan context more focus has been on green sustainable practices and their effects on manufacturing performance and the few studies on circular economy approach are based

only on waste management for instance Abong et al. (2021) had studies on green consumerism in Kenya and Musau (2021) studied the effects of green manufacturing in Kenya. The circular manufacturing practices effects on performance of manufacturing companies are yet to be fully explored in the Kenyan perspective hence this study.

Apart from the sparse information available on the subject, it is not adequate to only consider the technical and engineering performance of manufacturing systems as per the current available information. Perspectives of circular economy of economics, society and ethics ought to be incorporated into the key performance indicators for assessing performance improvements (Byrne et al., 2020). This study seeks to explore the relationship between circular manufacturing, supply chain integration and sustainability practices and how these factors collectively influence the performance of manufacturing companies in Kenya.

1.3. Specific Objectives

- i. To determine the effect of circular manufacturing on performance of manufacturing companies in Kenya.
- ii. To assess the moderating effect of circular supply chain reconfiguration on the relationship between circular manufacturing and performance of manufacturing companies in Kenya.

1.4. Study Hypothesis

H01: Circular manufacturing has no significant effect on the performance of manufacturing companies in Kenya.

H02: Circular supply chain reconfiguration has no significant moderating effect on the relationship between circular manufacturing and performance of manufacturing companies in Kenya.

2.1. Theoretical Review

2.1.1. Resource-Based View Theory

The resource-based view theory emphasizes an entity's resources as the fundamental determinants of competitive advantage and performance (Paul, 2012). The model states that having valuable, rare, inimitable, organized, and non-substitutable capabilities and resources enhances a firm's sustainable performance (Bhandari et al., 2020). The theory has been used in demonstrating the role of resources and capabilities in product innovation and how product innovation is related to overall firm performance. It highlights the importance of relational resources (Andersén, 2021).

The model operates on the assumption that companies within an industry may be unique or heterogeneous with respect to the bundle of resources that they control. The other assumption is that resource heterogeneity may be persistent over time as the resources used to implement firms' strategies are not perfectly mobile across firms. Resource heterogeneity or uniqueness is considered a necessary condition for a resource bundle to contribute to a competitive advantage

(Cool, 2002). Heterogeneity and immobility are not, however, sufficient conditions for sustained competitive advantage. The entity's resources must be in addition valuable, rare, and imperfectly imitable and sustainable to be source of sustained competitive advantage (Peteraf & Barney, 2003).

Organizations can look inside their companies' resources to find the sources of competitive advantage. For instance, circular manufacturing by use of affordable and reliable circular energy means, environmentally friendly raw material extraction and processing and endorsements of their circular practices in manufacturing using credible ecolabels which will bring green trust and awareness concerning the entity hence a competitive advantage can be a good reflection of the resource-based theory application. This can be tapped for tremendous benefits by marketers in providing the value of products offered in taking green marketing policies to the customers and other involved stakeholders (Alamsyah et al., 2020).

2.1.2. Strategic Choice Theory

Strategic choice is a systemic theory of strategy. According to Zhu (2012) the theory is built on an interaction mode where organizations adapt to their environment in a conducive manner that will enable achievement of their goals. It was developed by John Child (1972) and continues to provide a significant influence on the study of organizations and management (Harney, 2016). The variance of environmental conditions, whether the environment was dynamic or static, and organizational contingencies were seen to automatically produce a specific type of organizational response. This contingency approach served the objective of offering insights for what management should do (Harney, 2016). Strategic choice brings about managerial agency and decision making more directly into the equation. For Child (1972), strategic choice was defined as the process whereby power holders in an organization decide upon courses of strategic action. Managerial discretion is important in making the strategic choice and it ought to be informed by underlying values and belief (Harney, 2016).

Strategic choice being a systematic theory of strategy in this study is built on a notion of the ability of companies being able to adapt to their environment in a self-regulating manner to achieve their goals and the dynamics over time by choosing circular manufacturing practices in their operations. These operational choices which bring about circular economy aspects in the social, economic and environmental aspects of the companies hence giving them a competitive edge in the market. The strategic choice decisions determine the future strategy of the firm hence the strengths, weaknesses, threats and opportunities that can be exploited. This in turn determines the performance of the companies. It is therefore a paramount theory in consideration of circular reconfiguration practices which will affect the performance of any organization while taking into consideration return on investment This is because the Strategic Choice Theory details on the importance of taking the right action in a contradicting situation so as to achieve efficiency as a result of the choices picked.

2.2. Conceptual Framework

A conceptual framework is a set of broad ideas and principles taken from relevant fields of enquiry and used to structure a subsequent presentation. Mugenda and Mugenda (2016) define a conceptual framework as hypothesized model identifying the model under study and the relationship between study variables. Figure 1 presents the hypothesized relationship between the independent variables, the moderating variable and the dependent variable for testing in this study:

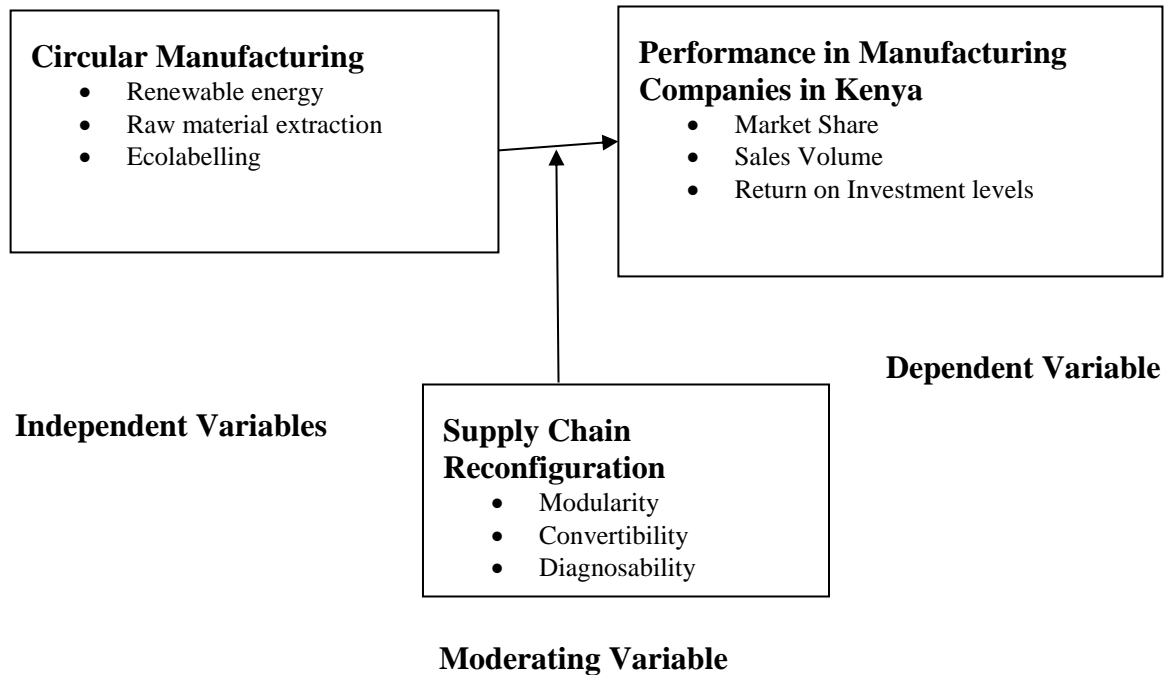


Figure 1: Conceptual Framework

2.2.1. Circular Manufacturing

The circular manufacturing flow management involves closing, intensifying and narrowing loops through moving from resource saving to resource capitalization practices and hence building a common framework of metrics and benchmarks to balance economics and environmental values (Hazen et al., 2020). It is notable that current consumption levels are unsustainable and account for an important share of the overall negative environmental impacts caused by human activities. Circular manufacturing is a model that puts into consideration environmental sustainability and resource optimization throughout the product life cycle with the aim of maximizing resource efficiency and minimizing negative effects to the environment. All this with the aim of reaping maximum economic and social benefits (Musau, 2021). The aim is to integrate the human-economic activity and the natural environment in a sustainable manner which can be attained by optimizing the socio-environmental system as a whole and not just its individual components. The material flows require that biological nutrients are re-circulated which for effective uptake,

requires knowledge and participation by the entire operations process in a circular supply chain (Garcia et al., 2021).

Renewable energy is that which can be produced in a way that protects the natural environment. It is often referred to as renewable, clean or circular energy and comes from natural sources or processes that are constantly replenished for instance sunlight or wind even if their availability depends on time and weather. They include solar energy, wind energy, hydroelectric energy, biomass energy and geothermal energy (Shinn, 2018). EPA which is a United States Environmental Protection Agency defines circular power as a subset of renewable energy which represents those renewable energy resources and technologies which provide the highest environmental benefit- zero emissions profile and carbon footprint reduction benefits (Scarlat et al., 2018).

Concerning raw material extraction, it is necessary to establish how far CE initiatives and the current use of secondary material from recycling are affecting extraction of virgin resources considering extraction is energy and material intensive and a cause of environmental damage. It is hence necessary to determine the relationship between the use of secondary materials and resource extraction so as to understand the extent to which a CE can contribute to performance of an entity while at the same time satisfying an ever-increasing consumer demand (Korhonen et al., 2018).

Eco labelling manufacturing attribute is one that is adopted to show that a product has been designed to do less harm to the environment than similar products and has fit all green requirements necessary in the circular supply chain. These products are most often slightly more expensive than conventional products and many companies with an environmental agenda use eco labelling to claim their environmental efforts and differentiate their products from similar, less sustainable alternatives (OECD, 2016).

2.2.2. Supply Chain Reconfiguration

Reconfigurability is used to measure quantitatively the capability of supply chain to easily change their structure and functions. Given the COVID 19 pandemic, fluctuating demand, market uncertainty and the emergence of new technologies, a more flexible and agile supply chain in response to the market trends is needed. Ensuring supply chain flexibility, agility, resilience, and viability requires the development of a reconfigurable supply chain that can cope with various market changes in the supply chain levels with the minimum resources time and cost (Zidi et al., 2022).

To stay responsive to evolving customer demands and to meet the need for greater product customizations, there is need for organizations to quickly reconfigure their manufacturing systems and supply chain. Supply chain reconfiguration is hence applied as a moderating variable as reconfiguration can alter the association between the independent and dependent variables by

either strengthening or diminishing the association according to operational circumstances of the organization (Tian & Guo, 2019).

Modularity based manufacturing practices is the application of unit standardization or substitution principles to create modular components and processes that can be configured into a wide range of end products to meet specific customer needs (Tu et al., 2004). These practices enable firms to achieve modularity in product design, production process design and organizational design which can be achieved when their components can be disaggregated and recombined into new configurations with little loss of functionality. Dividing a complex system into smaller modules and examining each piece separately can ease management in a business and increase benefits such as economies of scale, increased feasibility of product/components change, increased product variety and reduced lead time, ease of product upgrade, maintenance, repair and disposal among others thus implementing a reconfigurable manufacturing system (Omai et al., 2018).

To support these processes, convertibility is incorporated which involves having flexible and changeable dynamics in the manufacturing process which can easily be applied at the equipment, production system and assembly levels to dynamically and efficiently change the capabilities of the system, resources, and new configurations to adopt to the rapidly changing manufacturing environment hence increase and maintain efficient performance in the companies (Zidi et al., 2022).

To detect and correct failures quickly, the reconfigurable supply chain system must have a high degree of diagnosability which can be measured through parameters like detectability, predictability, and distinguishability. Detectability determines the time before detecting the failure, predictability which measures the time before the failure re-occurrence and distinguishability which measures the time necessary to identify the replaceable unit of a system that causes a failure. Bottom line, supply chain reconfiguration aspect of diagnosability is measured by considering two quantitative factors: supply chain visibility and detection time (Zidi et al., 2022).

2.2.3. The Concept of Performance

Performance is defined as the operational excellence to deliver leading customer experience (Trong, 2016). According to Byrne et al. (2020) performance is to be interpreted in relation to technical efficiencies and capabilities, agility, resilience and robustness of manufacturing companies. For a long time in history, the goals of organizations' existence was making of profits or return on investments but during the more recent years marketplace characteristics have changed as customers are demanding goods and services at a more quicker delivery, higher quality, better price and greater service excellence Nia et al. (2016) which also leads to increased awareness of the ecological dimension and the social dimensions such as people's fear of losing their jobs due to emerging technologies (Birkel & Müllerb, 2021).

Also, apart from economic performance, other stakeholders such as policy makers and non-governmental organizations (NGO)s are also showing interest in the social and environmental performance of companies (Schoggl et al., 2016). To thus achieve synergies in performance, the three interdependent dimensions of triple bottom line (TBL) concept are considered. They include economic, environmental and social aspects of performance (Birkel & Müllerb, 2021).

Sustainable performance of an organization refers to its ability to meet the needs and expectations of customers and other stakeholders on long-term, balanced by an effective management organization by organizing staff awareness by learning and applying appropriate improvements and innovation which in turn leads to an increase in market share and return on investments of the companies as a consequence of the social and economic aspects and effects of an organization (Stanciu, Constandache, & Condrea, 2014).

RESEARCH METHODOLOGY

3.1. Research Design

The study applied a cross-sectional research design in analysis. According to Shikokoti, Okoth & Abungana, (2024) cross-section survey design can be used for both analytical and descriptive purposes in that it can answer how or why a certain outcome might occur and summarize the said outcome using descriptive statistics Shikokoti, Okoth & Abungana, (2024).

3.2. Target Population and sample size of the Study

In this study, the target population was manufacturing companies in Kenya. This was to reach the entire Kenyan manufacturing segment to provide up to date information on circular supply chain operations as a country because different regions and sectors contain different information which will be important to capture thus making the results more conclusive in comparison to focus on one region and sector. The 2023 KAM directory has a listing of members by sectors, which contains a register of 14 sectors of those in manufacturing firms spread all over Kenya. The directory categorizes members per sector, which is defined by the services they produce, the type of raw materials they import or the products they manufacture. The population of all the registered members for the 14 sectors, as per the directory, was 1,048. The two service sectors of fresh produce and service and consultancy were eliminated to remain with the 12 manufacturing sectors because their focus is on the provision of services and not the actual manufacture of goods and products.

The 12 manufacturing sectors have a total population of 795 companies, which comprise the unit of analysis while the unit of observation was the organizational management officers conversant with the supply chain process and their assistants. Additionally, the sample size derived from the target population using the Slovin formula for this study was 266 respondents and is shown in Table 1.

Table 1: Classification of the Sample Size

Types of Sectors	Manufacturing Companies in the sector	Sample size
Building, Mining & Construction	49	16
Chemical & Allied	81	29
Energy, Electrical & Electronics	50	17
Food & Beverages	193	64
Leather & Footwear	17	6
Metal & Allied	87	29
Automotive	56	18
Paper & Board	58	19
Pharmaceutical & Medical Equipment	29	10
Plastics & Rubber	83	27
Textiles & Apparel	62	21
Timber, Wood & Furniture	30	10
Total	795	266

Source: Author (2026)

The stratified sampling method was used to put the population into distinct, independent strata that enable the researcher to draw inferences about specific subgroups that may be lost in a more generalized random sample, thus leading to more efficient statistical estimates (Creswell & Guetterman, 2018).

3.3. Data Collection Instrument

Data collection is how information is obtained from the selected subject of an investigation (Mugenda & Mugenda, 2016). The researcher collected primary data during the research. Primary data was collected using a questionnaire covering circular manufacturing practices and the performance of manufacturing companies in Kenya. The questionnaire contained closed-ended questions that limited the respondents to variables in which the researcher was interested.

3.4. Data Analysis

The objectives of the study were analyzed using descriptive statistics techniques and multiple regression models were fitted to the data to determine how the predictor/independent variables affect the response/dependent variable. The equation for circular manufacturing and the performance of manufacturing companies in Kenya is expressed in the following equation:

$$Y = \beta_0 + \beta_1 X_1 + \varepsilon$$

This study used multiple regressions analysis (hierarchical moderated method) to establish the moderating effect of Supply Chain Reconfiguration (Z) on the relationship between circular manufacturing and performance of manufacturing companies in Kenya. The regression model for the moderating effect was as follows;

$$Y = \beta_0 + \beta_1 X_1 + \beta_2 (X_1 Z) + e$$

Where:

Y = Performance of manufacturing companies

β_0 = Intercept coefficient or value of dependent variable when the independent variable is zero

β_1 = Coefficient for circular manufacturing

X_1 = Circular manufacturing

β_2 = Coefficients for interaction terms between supply chain reconfiguration and circular manufacturing

Z = Circular supply chain reconfiguration

e = Error term

PRESENTATION, ANALYSIS AND INTERPRETATION OF DATA

4.1. Results and discussion

Out of the 266 questionnaires administered among the respondents, 221 questionnaires were returned completely filled, representing a response rate of 83.1%.

4.2. Descriptive Statistics Analysis

In this section, the study presents the finding on the specific objectives of the study. On the Likert scale questions, the scale was 5 with 1 Strongly Disagree, 2 Disagree, 3 Moderate, 4 Agree and 5 Strongly agree. Means and standard deviations were used to interpret the results with a mean of 0-1.4 implied that the respondents strongly disagreed, a mean of 1.4-2.4 implied they disagreed, 2.5-3.4 suggest that they were neutral, a mean of 3.5-4.4 suggest they agreed, and a mean of 4.5-5 implies the respondents strongly agreed (Trochim, 2016).

4.2.1. Circular Manufacturing Practices

The 12-item scale assessed circular manufacturing practices across several areas, including organizational policies and standards, supplier selection, adherence to existing regulations, and circular metrics. The overall mean response score was 3.56, with a standard deviation of 1.035. This score falls within the interval range, indicating that respondents agreed that circular supplier

sourcing has an impact on the performance of manufacturing companies in Kenya. The results were as shown in Table 2 below:

Table 2: Circular Manufacturing

Circular Manufacturing	1	2	3	4	5	N	Mn	S Dev
Renewable energy is readily available and utilized in our production process	3	9	1	91	2	221	3.2	1.136
	0	2			5		0	
Renewable energy is used at a high rate in production and warehouse operation	4	9	1	85	2	220	3.1	1.138
	7	2			2		1	
The organization uses sustainable/renewable/circular technology that can reduce electric energy consumption	2	7	1	105	2	221	3.3	1.080
	2	7			5		6	
The organization is minimizing electricity costs through renewable energy	3	6	1	103	3	221	3.4	1.111
	9	5			1		1	
Our organization has relevant licenses needed for extraction of raw material	7	7	1	94	2	219	3.2	1.166
	6	3			9		8	
Our organization encourages the land to be restored after mining/extraction	8	7	1	92	2	221	3.2	1.163
	8	6			7		4	
	7	6	1	107	2	221	3.3	1.132
Our organization participates in planting of trees	9	2			6		4	
Our organization engages suppliers who responsibly extract raw material	1	2	1	114	6	220	4.0	0.944
	7	0			8		0	
Our organization performs frequent awareness on eco-label credibility	0	2	1	135	5	221	3.9	0.862
	6	0			0		5	
	2	2	1	130	5	221	3.9	0.894
Eco-labels on our products are visibly branded	3	0			6		7	
The eco-labels on our products are attainable, verifiable and measurable	2	2	1	131	5	221	3.9	0.898
	4	0			4		5	
Our organization uses products from suppliers with credible eco-labels	1	2	9	132	5	221	3.9	0.890
	6				3		5	
							3.5	1.035
Circular Manufacturing							6	

Key: 1 = strongly disagree, 2 = disagree, 3 = Neither agree nor disagree, 4 = agree, 5 = strongly agree

Source: Author (2026)

4.2.2. Supply Chain Reconfiguration

The second specific objective of the study was to assess the moderating effect of circular supply chain reconfiguration on the relationship between circular supplier sourcing and performance of manufacturing companies in Kenya. The supply chain reconfiguration constructs measured SC flexibility or the degree to which manufacturing companies can easily modify their SC structure to meet changing needs (Zidi et al., 2022). A 12-item scale was used for this construct. Areas of focus included modular design, circular inputs and sub-products, circular and efficient conversion, and emergency response. The responses to the SCR items are in Table 3.

Table 3: Supply Chain Reconfiguration Variables

Supply Chain Reconfiguration	1	2	3	4	5	N	Mn	S D
Our organisation uses the modular design of creating an item out of smaller, interchangeable parts or modules.	1	34	8	150	28	221	3.77	0.877
Our sub products and input in production leads to specialization	0	31	9	149	32	221	3.82	0.848
Circular sub-products and input in production enhances operations	1	29	13	151	26	220	3.78	0.837
Circular sub-products and input are easy to source	0	69	20	111	21	221	3.38	1.027
Our organisation manages conversion of circular material i.e., biodegradable material without use of toxic chemicals, to finished products	1	44	9	130	37	221	3.71	0.984
Our organisation has invested in machinery and systems that are used in conversion of input to finished products	1	23	11	137	49	221	3.95	0.854
Our organisation employs professionals who are knowledgeable of the company's production process	1	26	5	124	65	221	4.02	0.912
The conversion of raw material to finished goods in our organisation is effective	1	25	7	141	47	221	3.94	0.859
Our organisation has a laid down structure for adoption in operation	0	26	6	130	59	221	4.00	0.876
Our organisation can quickly diagnose issues within its supply chain	1	25	7	128	60	221	4.00	0.894
There are monitoring teams tasked with ensuring smooth operation of the company	0	26	6	128	61	221	4.01	0.882
Our organisation is quick in responding to emergency situations	1	24	6	133	57	221	4.00	0.874
Supply Chain Reconfiguration							3.87	0.894

Key: 1= strongly disagree, 2= disagree, 3 = neither agree nor disagree, 4= agree, 5= strongly agree

Source: Author (2026)

4.2.3. Manufacturing Performance

The study assessed participants' views of the performances of their organizations using a 12-item instrument. The questionnaire covered various performance aspects, including customer relations, product/service delivery/quality, technology integration, and financial performance. The questionnaire prompted participants to indicate their agreement with each item. Their responses are shown in Table 4. All the 12 items were assessed using positively worded statements. Mean scores were then computed for the items following the procedure outlined previously. The overall mean in the 12 items was 3.82 (SD = 0.911), an equivalent of 76.3%. In other words, on average, participants assigned a rating of 76.3% (high) to their organizations' manufacturing performance.

Table 4: Manufacturing Performance Variable

Manufacturing Performance	1	2	3	4	5	N	Mn	Std D
Our business has improved because of the trust with customers and suppliers	0	26	7	130	58	221	4.00	0.876
Our organization delivers services to its customers at a reduced cost	1	35	8	141	36	221	3.80	0.914
The integration of technology, people, business, and processes has enhanced our organization's competitive edge in the current digital age	1	21	7	147	45	221	3.97	0.811
Our organization can provide better products to our customers	1	25	6	146	43	221	3.93	0.844
Our organization has an Enterprise Resource management system that tracks sales volumes and stock turnover levels which enable the company to reorder with greater accuracy.	1	25	6	149	40	221	3.91	0.835
Our sales and inventory turnover levels are reported and forecasted effectively.	1	2	10	142	40	219	3.89	0.857
Our management of inventory turnover levels helps in managing production schedules	1	24	6	126	64	221	4.03	0.891
Proper management of inventory turnover levels promotes relationships	1	24	7	151	38	221	3.91	0.821
Our company has significant financial reserve to cover all potential needs	3	32	18	140	28	221	3.71	0.912
Our company's profits have increased for the last 3 years.	3	37	17	137	27	221	3.67	0.941
Our overhead costs have reduced for the last 3 years	4	73	14	107	23	221	3.33	1.097
Our company's procurement costs have reduced for the last 3 years	0	39	20	143	19	221	3.64	0.871
Manufacturing Performance							3.82	0.885

Key: 1= strongly disagree, 2= disagree, 3 = neutral, 4= agree, 5= strongly agree

Source: Author (2026)

4.3. Inferential Statistics Analysis

4.3.1. Correlation Test

The correlation analysis was conducted to examine the strength and direction of relationships between the study variables, particularly to assess potential multicollinearity among the independent variables and to understand how each variable related to manufacturing company performance. A correlation analysis was conducted using Spearman's correlation coefficient to examine the relationships between the study variables. The test was appropriate given the ordinal nature of the data collected through the Likert scale measurements. Table 5 presents the results of the Spearman Correlation Matrix for the study variables.

Table 5: Results of Spearman Correlation Matrix for Study Variables

		Performance of manufacturing companies
Circular manufacturing	Correlation Coefficient	-.103**
	Sig. (2-tailed)	.127
	N	221
Circular supply chain reconfiguration	Correlation Coefficient	.408**
	Sig. (2-tailed)	.000
	N	221

***. Correlation is significant at the 0.02 level (2-tailed).*

Source: Author (2026)

Circular manufacturing did not show statistically significant correlations with the performance of manufacturing companies ($r = -0.103$, $p > 0.05$). These results suggested that these practices might not have a direct linear relationship with company performance or that their effects might be mediated or moderated by other factors not captured in this correlation analysis. These findings disagree with those of Pinheiro et al. (2022) who found that circular design and circular manufacturing significantly enhance company performance by promoting resource efficiency, innovation, and environmental sustainability. Similarly, circular supply chain reconfiguration showed a moderate positive correlation with performance ($r = 0.408$, $p < 0.01$), suggesting that companies that were more adept at reconfiguring their supply chains in line with circular economy principles tended to perform better.

4.4. Hypothesis testing

4.4.1. Test for Hypothesis One

The first objective of the study was to determine the effect of circular manufacturing on performance of manufacturing companies in Kenya. The corresponding hypothesis was:

H_{01} : Circular manufacturing has no significant effect on the performance of manufacturing companies in Kenya.

A univariate analysis was therefore conducted to test the null hypothesis. From the model summary findings in Table 6, the r-squared for the relationship between circular supplier sourcing and performance of manufacturing companies in Kenya was 0.032; this is an indication that at 95% confidence interval, 3.2% variation in performance of manufacturing companies in Kenya can be attributed to changes in circular manufacturing. However, the remaining 96.8% variation in supply chain performance suggests that there are other factors other than circular manufacturing that explain performance of manufacturing companies in Kenya.

Table 6: Model Summary for Circular Manufacturing

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.178 ^a	.032	.027	.33158

a. Predictors: (Constant), Circular manufacturing

b. Dependent Variable: Performance of manufacturing companies

The ANOVA results for this hypothesis displayed in table 7 showed that the model was statistically significant ($F = 7.140$, $p < 0.001$). This indicates that circular manufacturing significantly influences the performance of manufacturing companies in Kenya. The significant F-statistic confirms that the predictor variable, circular manufacturing, contributes a small but meaningful proportion of the variance in performance. Since the F value is small at 7.140, it indicates that the model explains a significant portion of the variation in the performance of manufacturing companies in Kenya. These findings suggested that as manufacturing companies in Kenya increased their focus on circular manufacturing, their overall performance tended to improve. Additionally, the null hypothesis was rejected and the alternative hypothesis was upheld as the p value was below the significant value of 0.05 at 0.000, meaning that means that there is enough evidence to conclude that manufacturing does have a significant impact on performance.

Table 7: ANOVA for Circular Manufacturing

Model	Sum of Squares	df	Mean Square	F	Sig.
Regression	.785	1	.785	7.140	.008 ^b
1 Residual	24.078	219	.110		
Total	24.863	220			

a. Dependent Variable: Performance of manufacturing companies

b. Predictors: (Constant), Circular manufacturing

From the results in table 8, the following regression model was fitted.

$$Y(\text{Performance of manufacturing companies}) = 2.231 - 0.084X_4 (\text{Circular manufacturing}) + e$$

The coefficient results showed that the constant had a coefficient of 2.231 suggesting that if circular manufacturing was held constant at zero, performance of manufacturing companies in Kenya would be at 2.231 units. In addition, results showed that circular manufacturing coefficient was -.084 indicating that a unit increase in circular supplier sourcing would result in a negative 0.084 increase in supply chain performance. It was also noted that the P-value for circular supplier sourcing coefficient was 0.000 which is less than the set 0.05 significance level indicating that circular manufacturing was significant. Based on these results, the study rejected the null hypothesis and accepted the alternative that Circular manufacturing has a significant effect on the performance of manufacturing companies in Kenya

Table 8: Beta Coefficients for Circular Manufacturing

Model		Unstandardized Coefficients		Standardized Coefficients		Sig.
		B	Std. Error	Beta	t	
1	(Constant)	2.231	.084		26.532	.000
	Circular manufacturing	-.084	.031	-.178	-2.672	.008

a. Dependent Variable: Performance of manufacturing companies

4.3.2. Test for Hypothesis Two

The second objective of the study was to assess the moderating effect of circular supply chain reconfiguration on the relationship between circular manufacturing and performance of manufacturing companies in Kenya. Moderation happens when the relationship between the dependent variable and the independent variables is dependent on a third variable (moderating variable). The effect that this variable has is termed as interaction as it affects the direction or strength of the relationship between the dependent and independent variable. To achieve this

research objective, the study computed moderating effect regression analysis. Supply chain reconfiguration was introduced as the moderating variable.

H₀₅: Circular supply chain reconfiguration has no significant moderating effect on the relationship between circular manufacturing and performance of manufacturing companies in Kenya.

$$Y = \beta_0 + \beta_1 X_1 + \beta_2 (X_1 Z) + e$$

Where:

Y = Performance of manufacturing companies

β₀ = Intercept coefficient or value of dependent variable when the independent variable is zero

β₁ = Coefficient for circular manufacturing

X₁ = Circular manufacturing

β₂ = Coefficients for interaction terms between supply chain reconfiguration and circular manufacturing

Z = Circular supply chain reconfiguration

e = Error term

Table 9 Model summary between circular manufacturing and Manufacturing performance with the moderating variable of supply chain reconfiguration

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics				
					R Change	Square F Change	df1	df2	Sig. Change
1	.178 ^a	.032	.027	.33158	.032	7.140	1	221	.000
2	.443 ^b	.196	.185	.905	.196	17.67	1	221	.000

a. Predictors: (Constant), Circular manufacturing

b. Predictors: (Constant), Circular manufacturing, Supply chain reconfiguration

Table 9 shows the model summary which has a positive relationship; R= 0.032, between the circular manufacturing practices and Manufacturing performance. The combined linear effects of the variables explained 3.2 percent variance in the management. This implied that management was lowly predictable by the determinant. Additionally, there is the model summary 2 which has a positive relationship; R= 0.196, between the circular manufacturing practices and Manufacturing performance with the moderating variable of supply reconfiguration. The combined linear effects of the variables explained 19.6 percent variance in the manufacturing performance. This implied that manufacturing performance was still lowly predictable by the determinant with effect from supply chain reconfiguration.

Table 10 Anova table between circular manufacturing and Manufacturing performance with the moderating variable of supply chain reconfiguration

Model		Sum of Squares	Df	Mean Square	F	Sig.
1	Regression	.785	1	.785	7.140	.008 ^b
	Residual	24.078	219	.110		
	Total	24.863	220			
2	Regression	43.3906	3	14.4635	17.671	.000 ^c
	Residual	177.6094	217	.8185		
	Total	221.0000	220			

a. Dependent Variable: Manufacturing Performance

b. Predictors: (Constant), Circular manufacturing

c. Predictors: (Constant), Circular manufacturing, Supply Chain Reconfiguration

Table 10 shows the test of significance of the model using ANOVA between Circular manufacturing and Manufacturing performance. There is a total of 220 (N-1) degrees of freedom. With 1 predictor variables, the regression effect has 1 degrees of freedom. The regression effect was statistically significant; $F(1,219) = 7.140$, $p = .008$. The test of significance of the model using ANOVA between Circular manufacturing and Manufacturing performance with the moderating variable of Supply Chain Reconfiguration. There are a total of 220(N-1) degrees of freedom. With 3 predictor variables, the regression effect has 3 degrees of freedom. The regression effect was statistically significant; $F(3,217) = 17.671$, $p = .000$.

Table 11: Regression Analysis between circular manufacturing and Manufacturing performance with the moderating variable of supply chain reconfiguration

Model		Unstandardized Coefficients		Standardized Coefficients		Sig.
		B	Std. Error	Beta	t	
1	(Constant)	2.231	.084		26.532	.000
	Circular Manufacturing	-.084	.031	-.178	-2.672	.008
2	(Constant)	-0.0217	.0618		-.351	.000
	Circular Manufacturing	1.1370	.0621	.0365	.588	.000
	Supply Chain reconfiguration	1.3732	.0637	.3955	6.208	.000
	GM×SCR	-0.2859	.0657	-0.1341	-2.042	0.0424

a. Dependent Variable: Manufacturing Performance

Table 11 shows that out of the 1 predictors that displayed significant relationships, Circular manufacturing ($\beta = -.084$, $p < .05$) had a negative influence on the criterion variable. This implies that a change in one unit (going up) of a predictor, Manufacturing performance is predicted to go down by the standardized β -value shown in Table 11. For instance, if Circular Supplier

manufacturing goes up by 1-unit Manufacturing performance goes down by -.084. Further, by substituting the beta values as well as the constant term from the coefficient's findings for the first step regression modelling, the following regression model will be fitted:

$$Y = 2.231 - 0.084 X_1$$

Where X_1 is Circular manufacturing

The second model in Table 11 shows that out of the 1 predictors that displayed significant relationships, Supply Chain Reconfiguration ($\beta=1.3732$, $p<.05$) had a higher influence on the criterion variable with Circular Manufacturing ($\beta=1.1370$, $p<.05$) having a positive influence on the criterion variable as a moderating variable. This implies that a change in one unit (going up) of a moderating variable, the predictor goes up, Manufacturing performance is predicted to go up by the standardized β -value shown in Table 4.8. For instance, if supply chain configuration influences positively the Circular manufacturing goes up by one unit influencing Manufacturing performance by going up by 1.1370. Supply Chain Reconfiguration has a strong positive association with Manufacturing Performance, and it significantly moderates the Circular Manufacturing–Performance relationship via a negative interaction term.

By substituting the beta values as well as the constant term from model 2 emanating from the second step in regression modeling the following regression model was fitted:

$$Y = \beta_0 + \beta_1 X_1 + \beta_2 (X_1 Z) + e$$

$$Y = -0.0217 + 1.1370 X_1 + 1.3732(X_1 Z)$$

Where:

Y = Performance of manufacturing companies

β_0 = Intercept coefficient or value of dependent variable when the independent variable is zero

β_1 = Coefficient for circular manufacturing

X_1 = Circular manufacturing

β_2 = Coefficients for interaction terms between supply chain reconfiguration and circular manufacturing

Z = Circular supply chain reconfiguration

e = Error term

FINDINGS AND RECOMMENDATIONS

5.1. Findings

The study sought to find the effect of circular manufacturing on performance of manufacturing companies in Kenya. The study found a significant negative relationship between circular

manufacturing and manufacturing company performance. This unexpected result might be due to initial investments and adjustments required to implement circular manufacturing practices. It is good to note that the role that circular manufacturing plays in today's organizations cannot be under emphasized as it is considered vital for the success of circular economies. However, for the current study, the effect of this variable on performance was non-significant. As pointed out previously, this discrepancy could suggest that the circular manufacturing practices in the sampled firms were not adequate to produce significant performance gains. Additionally, the study considered circular manufacturing as a construct of energy utilization, raw material extraction, and eco-labelling. Such differences in variable definition may have contributed to the discrepancies in results. In either case, this discrepancy warrants further research. Overall, the findings support a significant moderating role of Supply Chain Reconfiguration in the relationship between Circular Manufacturing and Manufacturing Performance, while Supply Chain Reconfiguration also has a strong direct positive association with Manufacturing Performance

5.2. Conclusion

The study concludes that adoption of circular manufacturing practices may initially negatively impact company performance, likely due to the substantial investments and organizational changes required for implementation. The study revealed that there was a significant relationship between circular manufacturing practices and performance of manufacturing companies in Kenya. The findings also showed that circular manufacturing practices negatively influences the performance of manufacturing companies in Kenya. The study accepted the alternative hypothesis that there is a significant relationship between circular manufacturing practices and performance of manufacturing companies in Kenya. The study concludes that circular manufacturing practices is negatively related to performance of manufacturing companies in Kenya while Supply Chain Reconfiguration has a strong positive association with Manufacturing Performance, and it significantly moderates the Circular Manufacturing and organizational performance relationship negatively.

5.3. Recommendations

Manufacturing companies in Kenya should emphasize implementing circular manufacturing practices as a critical strategy to enhance performance. This is majorly because implementing circular manufacturing practices may lead to short-term performance declines due to restructuring costs, technology upgrades, and process adjustments but companies can address these challenges by planning phased implementation approaches. Gradual integration allows firms to assess the effectiveness of changes and minimize disruptions. This approach ensures a smoother transition to circular manufacturing while enabling firms to achieve long-term benefits, such as cost savings, enhanced operational efficiency, and improved environmental performance.

Additionally, when reconfiguring supply chains to support circular manufacturing, companies should carefully evaluate the scope and potential effects of these changes. In this case, companies

must assess the financial and operational impact of these changes while ensuring they do not compromise supply chain effectiveness and trust between the companies involved. Besides, conducting pilot programs, collaborating with stakeholders, and leveraging digital tools for data-driven decision-making will help the companies achieve the desired balance.

To build upon the findings of this study, the following further research areas are suggested: The study was limited to the variables: circular manufacturing practices with supply chain reconfiguration as a moderating variable. The study recommends that similar studies to be conducted with inclusion of other circular supply chain management practices variables and with a different moderating variable. Future research should also focus on a longitudinal study to assess the long-term effects of circular manufacturing practices on the performance of manufacturing companies in Kenya and also investigate the specific factors contributing to the short-term negative impacts of circular manufacturing practices on company performance.

Additionally, to enhance the quality and impact of the paper, it is suggested that future research incorporate a mixed-methods approach, combining quantitative data with qualitative insights from industry practitioners. This could provide a richer understanding of the barriers to implementing circular manufacturing practices and the contextual factors influencing performance. It is also good to note that the study focused on the entire manufacturing industry. Although the industry was selected as it is one of the largest sectors in the country, a comparative study of circular supply chain management practices across various industries in Kenya could help identify sector-specific challenges and best practices in circular economy implementation. Furthermore, other comparative studies touching the different sectors of the manufacturing industry in Kenya can be conducted to add on more knowledge of the industry.

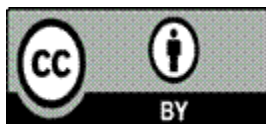
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