Research paper

Enhancing Sustainable Supply Chain Performance Through Circular Economy Practices: The Mediating Role of Supply Chain Capability and Flexibility

Esther Ntumy Lartey[1*], Emmanuel Amikiya[2]

Handling Editor: Michael Lieder

Received: 01.10.2024 / Accepted: 07.04.2025

Abstract

This paper investigates how circular economy practices influence sustainable supply chain performance, considering mediating factors like supply chain flexibility and capabilities. Using a descriptive survey design, data was gathered from 120 managers across ten manufacturing firms in Greater Accra, Ghana. All respondents completed and returned their questionnaires. The findings show that circular economy practices significantly enhance the sustainable supply chain performance of these firms. Additionally, supply chain capabilities and flexibility were found to partially and positively mediate this relationship. The study concludes the need to invest in building supply chain capabilities and fostering flexibility to maximize the benefits of circular economy initiatives.

Keywords: Circular Economy Practices (CEP) · Sustainable Supply Chain Performance (SSCP) · Supply Chain Capability (SCC) · Supply Chain Flexibility (SCF)

1. INTRODUCTION

The circular economy (CE) has gained significance due to sustainability's growing role in business management (Del Giudice et al., 2021). Supply chain capabilities (SCCs) play a key role in CE by optimizing resource use and reducing waste, which can help address environmental issues and turn these capabilities into effective supply chain management, fostering sustainable development (Han et al., 2020). Jabour et al. (2019) argue that CE requires balancing economic activities with environmental well-being, which enhances environmental, social, and economic outcomes. However, concerns have emerged regarding how supply chain performance aligns with green business opportunities and its associated capabilities (Weisz et al., 2023). The excessive use of natural resources and industrial waste remains a global challenge (Bag et al., 2022). With CE being a practical field influencing the creation of a more sustainable world, research on the topic has surged significantly (Dwivedi et al., 2023).

The growing pressure on policymakers to promote sustainable practices in product development, resource use, consumption, and disposal has brought significant attention to circular economy (CE) initiatives (Dubey et al., 2019). This shift reflects a major transformation in business management. Sustainable supply chain management is defined as the "systematic coordination of key inter-organizational business processes to improve long-term economic performance, while transparently integrating and achieving social, environmental, and economic goals" (Carter & Rogers, 2008, p. 368). To enhance socio-environmental and economic outcomes, it is crucial to align environmental sustainability with economic activities, fostering new business models (Jabbour et al., 2019). Implementing interconnected supply chain resources based on the 3 Rs—reduce, reuse, and recycle—can help build sustainable supply chains (Tseng et al., 2018). Research indicates that CE has been predominantly used to describe the sustainability of production systems, which are tied to various theoretical frameworks that aim to integrate different concepts (Sehnem et al., 2019). Thus, combining supply chain management performance with CE practices is essential, though empirical studies in this field remain limited.

[1] Wisconsin International University College
[2] Ghana Institute of Management and Public Administration
[*]Corresponding author: esther.lartey@st.gimpa.edu.gh

Academics have sought to drive significant change by integrating sustainability into supply chains and promoting more sustainable communities (Dubey et al., 2019). However, there is a notable lack of research examining circular economy (CE) from a supply chain perspective in both academic and professional literature, highlighting the need for comprehensive analysis. To incorporate CE principles effectively into business operations, companies must gather, clarify, and apply the relevant knowledge and data (Del Giudice et al., 2021). Supply chain integration, which involves information sharing and accessible technology between supply chain partners, as well as fostering collaboration, is essential (Leuschner et al., 2013). Yet, manufacturing companies often face challenges in reclaiming valuable materials that could be reused instead of ending up in landfills (Sharma et al., 2021). CE aims to help businesses overcome these challenges by reducing waste, pollution, climate change, and biodiversity loss (Schroeder et al., 2019). The cyclical use of resources has gained importance due to rising costs in managing waste and sourcing raw materials, as well as the growing need to minimize environmental impacts (Dubey et al., 2019). This approach aligns with sustainability concerns like resource-based production, industrial symbiosis, and ecosystem services. Despite these challenges, supply chain sustainability holds significant potential but faces obstacles in organizational, technological, and strategic areas. By developing a conceptual model that advances research and practices in CE and sustainable supply chain management, this study aims to bridge an important research gap.

This research introduces a conceptual framework that integrates supply chain flexibility and capabilities to bridge knowledge gaps and enhance the understanding of how circular economy (CE) practices influence sustainable supply chain performance. Managers are tasked with delivering engaging customer experiences while addressing their organization's evolving needs. Genovese et al. (2017) note that sustainable manufacturing and operations can gain competitive and managerial advantages by incorporating CE principles into sustainable supply chains. Developing circular supply chain models would foster the growth of recycling, waste management, and remanufacturing processes. These advancements could support future businesses in becoming more integrated, cooperative, and adaptable. Flynn et al. (2010, p. 58) further emphasize the need to explore how different dimensions of supply chain integration relate to various performance measures to fully understand the relationship between integration and performance.

Supply chain performance examines how effectively supply chain processes meet organizational objectives, focusing on key metrics such as efficiency, responsiveness, flexibility, and cost-effectiveness (Christopher, 2016). Ghomi-Avili et al. (2021) argued that producers might encounter capacity limitations within the supply chain, potentially disrupting the smooth functioning of production. These uncertainties can sometimes prevent manufacturers from exploring Circular Economy (CE) standards while also overlooking sustainable supply chain performance (Hina et al., 2022). However, by reducing consumption, pollution, and other factors, CE practices could offer the supply chain greater flexibility, improving its sustainability. Achieving long-term success requires effectively reallocating resources to maintain competitive advantages (Bag et al., 2022). Previous studies have examined supply chain capabilities and flexibility, focusing on areas such as information, relationships, technology, and processes to define various elements of supply chain integration (Flynn et al., 2010; Hina et al., 2022). The role of manufacturers in achieving sustainable supply chain performance has been a subject of interest for both researchers and industry experts (Wilhelm et al., 2016; Fontana et al., 2022).

Moreover, various studies have shown the impact of Circular Economy on supply chain performance, supply chain capabilities and flexibility respectively (Samad et al., 2021; Bag & Rahman, 2023; Bag et al., 2019). For instance, Bag and Rahman, (2023) indicated that sustainable supply chain flexibility had a significant and positive effect on circular economy target, ultimately enhancing sustainability. Bag et al (2019) revealed that dynamic remanufacturing capability has a positive influence on supply chain resilience. Flexible orientation is found to positively moderate the effect dynamic remanufacturing capability on supply chain resilience (Bag et al., 2019). The aforementioned studies have shown relationship among circular economy on supply chain performance, supply chain capabilities and flexibility. Despite the extensive review on these available studies, it appears there is a gap on mediating role of supply chain capabilities and flexibility in the relationship between circular economy and sustainable supply chain performance among manufacturing firms, especially in Ghana. From the researcher's view, the strength of supply chain capabilities and flexibility may cause circular economy to have significant impact on sustainable supply chain performance. Therefore, the current study addresses the gap by examining the mediating role of supply chain capabilities and flexibility in the relationship between circular economy and sustainable supply chain performance among manufacturing firms in Grater Accra, Ghana.

The proposed model, as illustrated in Figure 1, was evaluated to determine whether supply chain capability and supply chain flexibility mediate the relationship between circular economy practices and sustainable supply chain performance. The hypotheses formulated to test this model are as follows:

1. H_1: There is a significant impact of circular economy practices on sustainable supply chain performance
2. H_1: There is a mediating effect of supply chain capability in the relationship between circular economy practices and sustainable supply chain performance
3. H_1: There is a mediating effect of supply chain flexibility in the relationship between circular economy practices and sustainable supply chain performance

2. REVIEW OF RELATED LITERATURE

2.1 Circular Economy Practices, Sustainable Supply Chain Performance, Supply Chain Capabilities, and Supply Chain Flexibility

Pearce and Turner (1990) were pioneers in the use of circular economy (CE) concepts. The foundations of CE techniques focus on resource transformation, utilization, circulation, and product reclamation (Bag et al., 2022). Examples of circular business models include "closing raw material loops," "enhancing product functionality," and "shifting from ownership to service provision" (Rogge & Reichardt, 2016). Patwa et al. (2020) defined CE as "an industrial system designed to be restorative or regenerative by intention." CE aims to optimize and conserve resources, transforming environmental assets into diverse, marketable products and services that benefit businesses, consumers, and stakeholders alike (Del Giudice et al., 2021; Malhotra & Srivastava, 2023). For instance, Unilever contributed to the CE movement by developing a "design for recyclability," which not only enhances recycling efforts but also introduces a new business model by increasing the use of refills (Patwa et al., 2020). Companies are increasingly adopting CE practices to support technologies and business models focused on longevity, renewability, reuse, and repair. This approach maximizes the use of existing resources, minimizes raw material consumption, and reduces associated waste (Bag et al., 2022). Manufacturing firms, in particular, need to embrace CE practices to deliver their products and services in innovative, dynamic, and environmentally responsible ways, thereby creating sustainable economic opportunities (Malhotra & Shaiwalini, 2023; Kouhizadeh et al., 2023). A flexible circular supply chain, as noted by de Campos et al. (2017), helps reduce waste, ultimately benefiting the business model.

Sustainable supply chain capabilities have been developed to achieve both market share and organizational profit objectives, while simultaneously reducing environmental risks and enhancing environmental efficiency (Sehgal et al., 2023). Additionally, collaborating with business partners and improving the organization's "green image" strengthens and expands the organization (Zhu et al., 2011; Malhotra et al., 2022). Specifically, eco-friendly supply chain strategies benefit manufacturing and logistics companies by incorporating environmental considerations into the designs of both forward and reverse logistics processes (Diabat & Govindan, 2011). These capabilities also aid in the creation of sustainable products by reducing packaging and minimizing waste (Song et al., 2022). Moreover, they help assess suppliers based on their environmental performance, particularly by evaluating reductions in carbon emissions linked to product transportation (Samad et al., 2021; Malhotra, 2022). Sustainable supply chain strategies also implement innovative approaches to assess suppliers' environmental performance, cutting operational waste costs and improving the environmental quality of products (Sarma et al., 2023). By mitigating environmental risks, these strategies support organizations in achieving profit and market share targets (Samad et al., 2021). However, supply chain integration also influences sustainable supply chain performance in terms of sustainable supply chain capabilities (Samad et al., 2021).

Practices related to the circular economy improve the flexibility and competence of the supply chain, which results in sustainable performance (Mangla et al., 2022). A positive outlook and an increase in supply chain managers' CE practices are effectively sparked by this sustainable supply chain performance (Ekezie & Hong, 2023), which results in a comprehensive, sustainable supply chain performance. The ability of a supplier to manage production resources while increasing the possibility of being more adaptable in meeting customers' requests is known as supply chain flexibility (Chu et al., 2012). In order, to reduce labour costs, energy waste, transportation expenses, and material costs, supply chain flexibility is built at the process level (Bag et al., 2022). According to Upton (1994, p. 73), flexibility is "the ability to change or react with little penalty in time, effort, cost, or performance." Supply chain flexibility specifically refers to the function's capacity to respond to changes in the environment (Rojo et al., 2020). It is composed of the following: "distribution flexibility—a company's ability to manage its distributors, warehouses, loading capabilities, and other distribution installations

effectively and efficiently; sourcing flexibility—the availability of materials and services and the capacity to purchase them in accordance with changing needs; operating system flexibility—the capacity to provide products with a wide variety of characteristics, combinations, and volumes to satisfy multiple customer specifications." Lastly, information systems flexibility—a company's ability to adapt its information systems to changing market circumstances, especially in instances of unexpected misfit (Rojo et al., 2020, p. 12). Businesses can respond to market shifts and favourably, impact the performance of a sustainable supply chain by enhancing the adaptability of their products through the implementation of sustainable practices, such as using recycled materials and quickly receiving environmental data (Bai et al., 2020). The benefits of supply chain flexibility on organizational performance have been widely acknowledged by previous research (Blome et al., 2013). Flexibility in the supply chain encompasses a variety of characteristics that affect manufacturing companies. Hence, a supply chain needs to "(a) sense the external stimulus; (b) decide the response to the stimulus; (c) carry out the decided response; (d) monitor the effect of response; and (e) take corrective action if necessary" in order to remain flexible. Singh and colleagues, 2020, pp. 162-163. "(a) ability to sense the stimulus in a short time; (b) availability of strategic and tactical options to decide the response; (c) availability and scalability of resources for carrying out the decided response; and (d) presence of right metrics to measure the effect of the response; etc." are some of the capabilities that the supply chain needs in order to proceed. (Page 163, Singh et al., 2020). It is difficult for companies to produce and sell the products in the competitive market without the previously mentioned flexibility, particularly for those involved in CE remanufacturing operations.

2.2 Theoretical Framing

2.2.1 Stimulus-Organism-Response Model

The stimulus-organization-response (S-O-R) model effectively outlines how sustainable and dynamic supply chain performance operates within organizations and their environmental policies. Introduced by Mehrabian and Russell in 1974, the model draws on extensive research in social sciences, especially psychology, and reflects the actions of businesses and consumers, as noted by Jacoby (2002). In this framework, the "organism" signifies the emotional and cognitive processes that mediate the relationship between stimulus and response (Eroglu et al., 2001). The "response" refers to the resulting action or inaction (Kudla & Klaas-Wissing, 2012), while the "stimulus" is any factor that triggers action or heightened activity (Sherman et al., 1997). Thus, the model illustrates how a perceived stimulus generates internal feelings in customers or employees (the organisms), which ultimately translate into behaviors and actions (the responses). Bagozzi (1988) emphasizes that the S-O-R model focuses on external stimuli related to an individual's environmental context. Notably, within the cause-and-effect framework, both the stimulus and the response are observable factors that enable the organism to deduce behavioral patterns during decision-making processes. This model can also be applied to the interactions among buyers, agents, and suppliers, where "stimulus" encompasses various production processes, including order fulfillment, pricing, information accessibility, and marketing efforts.

In this study, we explore how circular economy practices act as a driving force. Here, "organism" signifies the supply chain's adaptability and its ability to respond, while manufacturers' goals for sustainable supply chain performance reflect this reaction. Additionally, by leveraging various resources such as pricing, order fulfillment, and promotion, circular economy strategies can enhance a company's supply chain performance while addressing its evolving manufacturing requirements (Saghiri et al., 2017). Consequently, this research builds on the S-O-R model by proposing circular economy practices on sustainable supply chain performance, and the role of supply chain capability and flexibility. This, in turn, fosters the development of supply chain flexibility and capabilities, ultimately supporting sustainable supply chain performance.

The Stimulus-Organism-Response (S-O-R) model is chosen for this study because it effectively captures the mechanism through which external environmental stimuli, such as circular economy practices (stimulus), influence internal organizational factors like supply chain capabilities and flexibility (organism), which in turn drive sustainable supply chain performance (response). Unlike other models that may focus solely on linear causality or static relationships, the S-O-R framework accommodates the dynamic interactions between external pressures, internal adaptations, and performance outcomes. This model is particularly relevant in the manufacturing sector, where firms must continuously adapt their supply chain capabilities to align with circular economy principles while maintaining sustainability. The S-O-R model thus provides a comprehensive lens to examine how supply chain flexibility and capabilities mediate the impact of circular economy adoption on sustainable supply chain performance, making it a more suitable choice over alternative frameworks.

This study, therefore, used this model to determine the effect circular economy practices on sustainable supply chain performance, the role of supply chain capability and flexibility

2.3 Research Framework

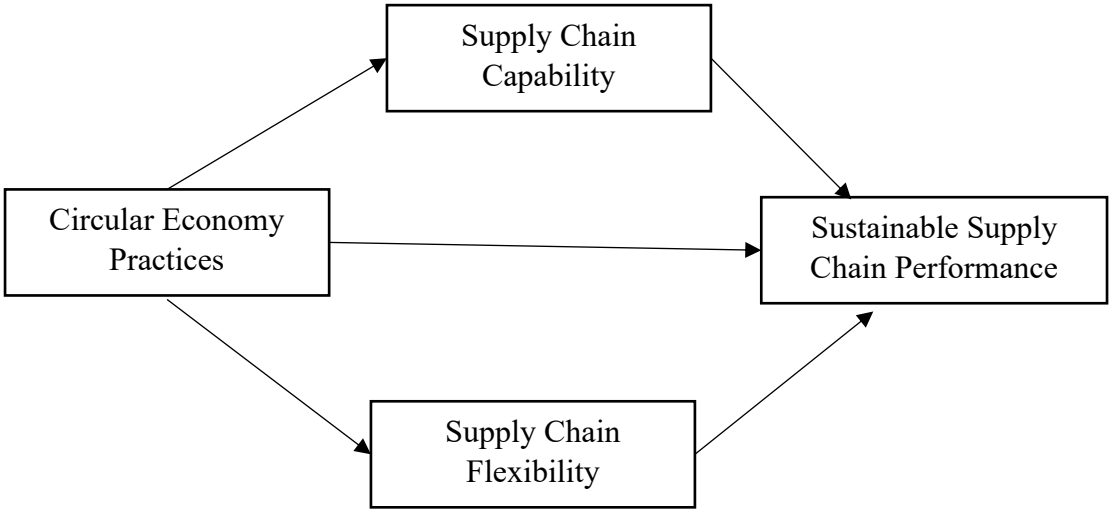

Figure 1. The Effect of Circular Economy Practices on Sustainable Supply Chain Performance, the Role of Supply Chain Capability and Flexibility. Source: Conceptualised by author

3. METHODOLOGY

3.1 Methods and Materials

In order to gather descriptive data from a sample chosen from the wider community at a specific period, this study used a descriptive survey approach. The information gathered depicts the situation as it existed during the study. Ten manufacturing companies in the Greater Accra Region of Ghana participated in a cross-sectional survey to find out how supply chain flexibility and competency, as well as the impact of circular economy practices, affect sustainable supply chain performance.

Sampling, as defined by Burns and Grove (2003), involves selecting a group of individuals, events, or behaviors for research purposes. The study purposively sampled two manufacturing companies from each of the following manufacturing sectors in Greater Accra, Ghana: chemical manufacturing firm, mental product manufacturing firm, paper manufacturing firm, textile and clothing manufacturing firm, and plastic and rubber manufacturing firm. Creswell and Clark (2017) suggests that being purposeful means identifying participants that might provide insight into your research question. The various sampled manufacturing firms were made up of 120 managers who were involved in circular economy practices. Details of the sampled manufacturing firms and their respective number of managers are presented in Table 1. In addition, the census method was used to engage all 120 managers from the sampled manufacturing firms in Greater Accra, Ghana. All 120 managers completed and returned the questionnaires, achieving a 100% response rate.

An adapted questionnaire was utilized for the study. The circular economy scale consisted of seventeen items, derived from the works of Zhu et al. (2011), Jabbour et al. (2019), and Gupta et al. (2019). A five-item scale for supply chain capabilities was adopted from Bowen et al. (2001), while an eight-item scale for supply chain flexibility was adapted from Merschmann and Thonemann (2011). Additionally, an eleven-item scale for sustainable supply chain performance was based on Green et al. (2012). The reliability scores for the scales were as follows: circular economy scale (α = .74), supply chain capabilities scale (α = .71), supply chain flexibility scale (α = .79), and sustainable supply chain performance scale (α = .82).

Data on the demographic characteristics of respondents were analysed using frequencies and percentages. Data for research objective one, two and three was analysed using SEM path analysis with 1,000 bootstrap samples. The data was processed and analysed using SPSS version 25 and JAMOVI software version 2.3.2.

4. RESULTS

4.1 Demographic Characteristics of Respondents

The demographic characteristics examined in this study include respondents' gender, education level, departmental affiliations within their manufacturing firms, and years of service, as detailed in Table 1. The results indicated that 57% of the respondents were male, while 43% were female. This suggests that, although males constituted the majority, the sample also included female participants, reflecting no gender bias in the sample size. However, the findings indicate a predominance of males in employment within manufacturing firms.

Furthermore, 66% of the respondents held bachelor's degrees, showing that most possessed the necessary qualifications for their positions. The study also indicated that the majority of respondents were from textile and clothing manufacturing firm (30%). In terms of departmental representation, a substantial portion of respondents (62%) belonged to the procurement and management departments, which play crucial roles in procurement activities. Additionally, 51% of the respondents had over five years of experience, indicating they were well-acquainted with procurement practices in their organizations.

Table 1. Demographic Characteristics

		Frequency	**Percentages**
Gender	Male	68	57
	Female	52	43
	Total	**120**	**100**
Education	Diploma	12	10
	Degree	79	66
	Masters	29	24
	Total	**120**	**100**
Manufacturing Firms	Chemical manufacturer	22	18
	Metal product manufacturer	18	15
	Paper manufacturer	24	20
	Textile and clothing	30	24
	Plastic and rubber manufacturer	26	23
	Total		
Department	Procurement	42	35
	Management	32	27
	Administration	31	26
	Accounts	15	12
	Total	**120**	**100**
Job duration	1-4 years	35	29
	5-8 years	61	51
	9-12 years	14	12

Above 12 years	10	08
Total	**120**	**100**

Source: Field Data, 2024

4.2 Preliminary Analysis

Prior to testing the model, a confirmatory factor analysis (CFA) was conducted to validate the reliability and validity of the variables. Table 2 presents the details of the confirmatory factor analysis for circular economy practices, supply chain performance, supply chain capacity, and supply chain flexibility

Table 2. Confirmatory Factor Analysis

Construct And Items	Loading	CR	Alpha	AVE
Circular economy practices (CEP)		.95	.91	.77
CEP1	.95			
CEP2	.81			
CEP3	.81			
CEP4	.90			
CEP5	.93			
CEP6	.84			
CEP7	.86			
CEP8	.95			
CEP9	.94			
CEP10	.86			
CEP11	.74			
CEP12	.80			
CEP13	.76			
CEP14:	.72			
CEP15:	.70			
CEP16:	.80			
CEP17: Re	.81			
Sustainable supply chain performance (SSCP)		.97	.91	.77
SSCP1	.86			
SSCP2	.85			
SSCP3	.93			
SSCP4	.93			
SSCP5	.80			
SSCP6	.85			
SSCP7	.88			
SSCP8	.91			
SSCP9	.92			
SSCP10	.88			
SSCP11	.81			
Supply chain capability (SCC)		.92	.84	.70
SCC1	.85			
SCC2	.80			
SCC3	.86			
SCC4	.83			
SCC5	.84			
Supply chain flexibility (SCF)		.91	.80	.55
SCF1	.79			
SCF2	.70			
SCF3	.60			
SCF4	.80			
SCF5	.81			
SCF6	.71			
SCF7	.71			
SCF8	.81			

The study assessed the measurement model through the constructs' scale reliability, discriminant validity, and convergent validity. We evaluated scale reliability using Cronbach's alpha values, total correlation coefficients, and composite reliability (CR). Table 2 displays the results obtained using SPSS AMOS version 21. Notably, the Cronbach's alpha values were above the acceptable threshold of 0.70 (Hair et al., 2009), the total correlation coefficients exceeded 0.30, and the CR estimates also surpassed the 0.70 threshold (Fornell and Larcker, 1981). This confirms the reliability of the scales.

Additionally, convergent validity was assessed through factor loading and average variance extracted (AVE) values. Factor loading values were above the benchmark of 0.60, and all AVEs exceeded the threshold of 0.50 (Fornell and Larcker, 1981), indicating that convergent validity was achieved. We also conducted confirmatory factor analysis (CFA) using SPSS AMOS version 21, which indicated a good fit between the dataset and the measurement model, with the following results: normed $\chi^2 = 2.216$, CFI = 0.909, IFI = 0.904, TLI = 0.921, and RMSEA = 0.066.

4.3 Path Analysis

The model was tested to determine the impact of circular economy practices on sustainable supply chain performance, along with the mediating roles of supply chain capability and supply chain flexibility in this relationship. The analysis was conducted using structural equation modeling (SEM) with a bootstrap sample of 1000 and bias-corrected confidence intervals. In this model, circular economy practices served as the predictor variable, while sustainable supply chain performance was the criterion variable. Supply chain capability and supply chain flexibility acted as the mediation variables. All variables were measured on a continuous scale. The details of the results are presented in Table 3 and Figure 2.

Table 2. Circular Economy Practices, Sustainable Supply Chain Performance, Supply Chain Capability and Supply Chain Flexibility

					95% C.I.		
Hypothesis	Type	Effect	Estimate	SE	Lower	Upper	P
H1	Total	CEP ⇒ SSCP	0.46	0.05	0.36	0.56	< .001
	Direct	CEP ⇒ SSCP	0.22	0.05	0.13	0.32	< .001
H2	Indirect	CEP ⇒ SCC ⇒ SSCP	0.06	0.02	0.02	0.09	0.001
H3		CEP ⇒ SCF ⇒ SSCP	0.18	0.03	0.12	0.25	< .001

Significant, $p < .05$. $R^2 = .18$. Circular Economy Practices (CEP), Sustainable Supply Chain Performance (SSCP), Supply Chain Capability (SCC), Supply Chain Flexibility (SCF).

4.4 Hypothesis One

The results presented in Table 2 indicated that circular economy practices account for 18% of the variation in sustainable supply chain performance. Additionally, the findings revealed a positive prediction of sustainable supply chain performance by circular economy practices, with a coefficient of B = .46 and a bootstrap 95% confidence interval of (.36, .56). This suggests that circular economy practices significantly influence sustainable supply chain performance.

4.5 Hypothesis Two

The findings revealed that circular economy practices have a direct impact on sustainable supply chain performance, with a coefficient (B) of .22 and a 95% bootstrapped confidence interval (CI) of (.05, .13). Furthermore, supply chain capability (B = .06, Boot 95% CI [.02, .09]) partially and positively mediated the relationship between circular economy practices and sustainable supply chain performance (see Table 2).

4.6 Hypothesis Three

More so, the results of the study revealed that supply chain flexibility (B = .18, Boot 95% CI [.03, .12]) partially and positively mediate the relationship between circular economy practices and sustainable supply chain performance (see Table 2). Notably, supply chain flexibility (B = .18) had a stronger mediating effect compared to supply chain capability (B = .06). These results suggest that both supply chain capability and flexibility

enhance the effectiveness of circular economy practices in influencing sustainable supply chain performance. Figure 2 illustrates the structure of the path model.

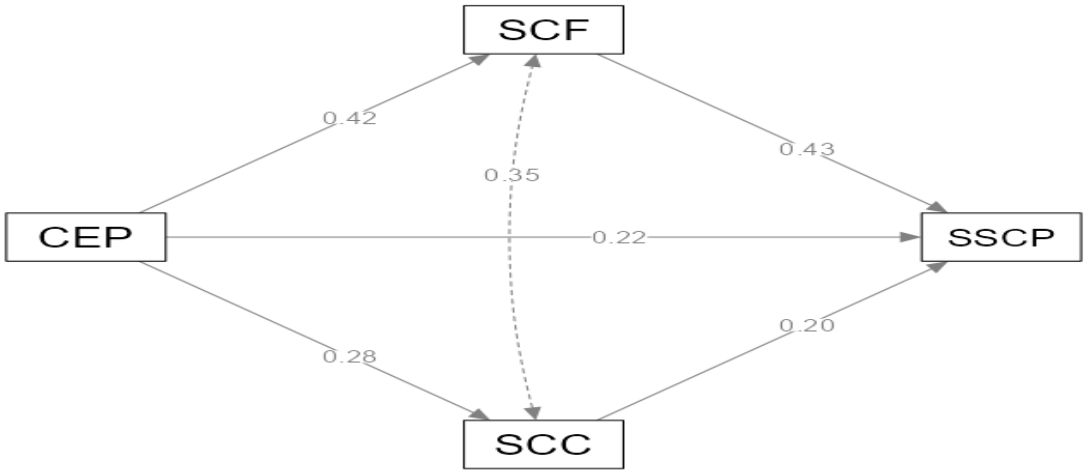

Figure 2. Structure of the Mediation Path Model

5. DISCUSSION

The study results revealed that circular economy practices significantly impact sustainable supply chain performance of manufacturing firms in Greater Accra. This implies that circular economy practices help sustain the supply chain activities of most manufacturing firms in Accra. The plausible reason for these results is that any manufacturing company would want to be cost-effective to meet maximum production or supply, however, it is reasonable for manufacturers to consider circular economy of their products to meet their target production or supply. The findings of this study align with existing literature (Del Giudice et al., 2021; de Campos et al., 2017; Edwin et al., 2022). For example, the results of the study were consistent with Del Giudice et al. (2022) who demonstrated that circular economy (CE) practices facilitate the conservation and optimization of available resources, enabling the transformation of environmental resources into various usable products and services that circulate among firms, consumers, and markets. Additionally, the results of the study were in harmony with de Campos et al. (2017) highlighting that a flexible circular supply chain can reduce waste, thereby positively influencing the business model. Moreover, the study's findings also collaborate with Edwin et al (2022) who revealed that circular economy (CE) significantly mediates between Big Data Analytics (BDA) capabilities and sustainable supply chain (SSC) performance. Amin et al (2024) also found a relationship between circular economy practices and sustainable performance which was similar to the findings of the current study.

More so, the study's results discovered that supply chain capability and flexibility had an indirect role on circular economy practices and it's impact on sustainable supply chain performance in manufacturing firms in Greater Accra. This means Supply Chain capability and supply chain flexibility complement circular economy practices to have an impact on sustainable supply chain performance in manufacturing firms in Greater Accra. The results suggest that for manufacturing firms in Grater Accra to leverage circular economy practices to strengthen the sustainability of their supply chain performance, they should enhance supply chain capability and flexibility. Additionally, good circular economy practices are complemented by flexibility with cost, labour, and logistics to maintain a sustainable supply chain. Hence, it is not surprising for manufacturing firms in Greater Accra complementing circular economy with supply chain flexibility and supply capacity for sustainable supply chain performance. The study's results are in line with earlier research (Mangla et al., 2022; Samad et al., 2021; Bag & Rahman, 2023; Bag et al., 2019). Specifically, the results of the study aligned with Mangla et al. (2022) study which found that circular economy practices improve supply chain capability and flexibility, which in turn contribute to sustainable supply chain performance. Furthermore, Samad et al. (2021) identified that the integration of the supply chain significantly affects sustainable supply chain performance within the context of sustainable supply chain capabilities. The results of the study were similar to Bag and Rahman, (2023) indicating that sustainable supply chain flexibility had a significant and positive effect on circular economy target. Ultimately, enhancing sustainability. Bag et al (2019) revealed that dynamic remanufacturing capability has a positive influence on supply chain resilience. Flexible orientation is found to

positively moderate the effect of dynamic remanufacturing capability on supply chain resilience (Bag et al., 2019).

The findings of the current study which state that supply chain capability and flexibility mediated the relationship between circular economy practices and sustainable supply chain performance confirmed the proposed model. The proposed model was built on the S-O-R model by proposing that circular economy practices on sustainable supply chain performance, the role of supply chain capability and flexibility. Hence, the final model (See Figure 2) confirmed the original model (See Figure 1), both models indicated that supply chain capability and flexibility play a role in the relationship between circular economy practices and sustainable supply chain performance.

The findings of this study highlight the pivotal role of circular economy practices in enhancing the sustainable supply chain performance of manufacturing firms in Greater Accra. By focusing on resource efficiency, waste minimization, and the reuse of materials, firms that adopt circular economy principles are better positioned to improve their environmental and economic outcomes. This underscores the importance of transitioning from traditional linear supply chain models to more sustainable and circular approaches, particularly in developing regions where resource constraints and environmental challenges are prominent.

Furthermore, the study revealed that supply chain capability and supply chain flexibility serve as significant mediators in the relationship between circular economy practices and sustainable supply chain performance of manufacturing firms in Greater Accra. These mediators amplify the benefits of circular economy practices by enabling firms to adapt swiftly to changes in demand and supply, optimize operational processes, and strengthen their competitive advantage. The partial mediation suggests that while circular economy practices directly influence supply chain performance, their full potential is realized through the enhancement of these dynamic supply chain attributes.

Overall, the research provides valuable insights for policymakers, managers, and practitioners in the manufacturing sector, especially in Greater Accra. It emphasizes the need to invest in building supply chain capabilities and fostering flexibility to maximize the benefits of circular economy initiatives. These findings advocate for strategic interventions, such as training programs, technological advancements, and collaborative partnerships, to support the adoption and integration of circular economy principles in supply chain operations. Ultimately, this approach contributes to sustainable industrial growth and long-term environmental stewardship.

6. RECOMMENDATIONS

Based on the findings of this study, several key recommendations can be made to enhance the implementation and benefits of circular economy practices in the manufacturing sector in Greater Accra. First, policymakers and industry stakeholders should prioritize the development and promotion of policies that incentivize the adoption of circular economy principles. Tax incentives, grants, and subsidies can encourage firms to invest in sustainable technologies and practices, such as recycling, waste reduction, and the use of renewable resources. These measures can accelerate the transition from linear supply chain models to circular, sustainable systems.

Second, manufacturing firms should invest in building their supply chain capabilities to fully leverage the benefits of circular economy practices. This includes adopting advanced technologies such as automation, data analytics, and artificial intelligence to enhance operational efficiency and decision-making processes. Strengthening supply chain capabilities will enable firms to optimize resource use, improve product lifecycle management, and reduce environmental impacts.

Third, firms should focus on enhancing supply chain flexibility to better respond to dynamic market conditions and evolving consumer demands. This could involve diversifying supplier networks, implementing agile production processes, and fostering collaborative partnerships with stakeholders across the supply chain. By improving flexibility, firms can mitigate risks, adapt to changes, and sustain their competitive advantage in a rapidly changing business environment.

Lastly, capacity-building initiatives, such as training programs and workshops, should be implemented to raise awareness and build expertise in circular economy practices and sustainable supply chain management. Collaboration between government agencies, industry associations, and educational institutions can play a critical role in equipping managers and employees with the skills needed to effectively integrate these practices into their operations.

7. SUGGESTIONS FOR FUTURE STUDIES

Further studies can be carried out on the impact of circular economy and environmental performance. The study can also be replicated in manufacturing firms in other regions or countries, since variations in internal polices might have impact on the results.

8. LIMITATIONS

The limitation of the study is its potential inability to capture the depth and complexity of human experiences, as it focuses on numerical data and statistical analysis. This approach often relies on structured tools like surveys, which may not fully account for contextual factors, individual perceptions, or nuanced behaviors. Additionally, the study was constrained by its dependence on predefined variables and hypotheses, potentially overlooking unexpected insights. Sampling biases, measurement errors, and the generalization of findings to diverse populations also pose challenges, particularly when the study lacks representation or sufficient sample size.

ACKNOWLEDGEMENTS

The authors sincerely thank all the managers in the various industries for their support during the data collection exercise.
The journal would like to thank Desislava Bekyarova for their administrative assistance throughout the publication process.

AUTHOR CONTRIBUTIONS

Esther Ntumy Lartey: Conceived the idea and performed the analysis
Emmanuel Amikiya: Prepared the initial draft of the manuscript

DECLARATIONS

Competing interests: The authors declare no competing interests.

APPENDIX

QUESTIONNAIRE

This questionnaire aims to collect data that will help the researcher to examine, "Enhancing Sustainable Supply Chain Performance through Circular Economy Practices: The Mediating Role of Supply Chain Capability and Flexibility" The exercise is for academic purposes only. Whatever information you give will be kept confidential. Thank you for your support

1. SECTION A

BACKGROUND DATA OF RESPONDENTS.

Please tick (√) or provide the appropriate response.

1. What is your sex?
   a. Male [ ]
   b. Female [ ]

2. What is your level of education?
   a. Diploma [ ]
   b. Degree [ ]
   c. Masters [ ]

3. Which of manufacturing sectors do you work?
   a. Chemical manufacturing company [ ]
   b. Metal product manufacturing company [ ]
   c. Paper manufacturing company [ ]
   d. Textile and clothing manufacturing company [ ]
   e. Plastic and rubber manufacturing company [ ]

4. Which Department do you work?
   a. Procurement [ ]
   b. Management [ ]
   c. Administration [ ]
   d. Accounts [ ]

5. What your years of job experience ?
   a. 1-4 years [ ]
   b. 5-8 years [ ]
   c. 9-12 years [ ]
   d. Above 12 years [ ]

2. SECTION B

CIRCULAR ECONOMY PRACTICES

Please read carefully the following statements and indicate to the best of your knowledge whether the degree to which you agree or disagree with the following statements.

Circular economy practices (CEP)	Strongly Disagree	Disagree	Agree	Strongly Disagree
The company does total quality environmental management				
The company does environmental auditing programs such as ISO 14000 Certification				
The company does eco-labelling of products				
The company does pollution prevention programmes CEP4				
The company Incorporates environmental factors in internal performance evaluation system				
The company Generates environmental reports for internal evaluation purposes				
The company Design products with the objectives to reduce consumption of materials and energy				
The company design products for reuse, recycle, recovery of material parts				
The company design products to avoid or reduce the use of hazardous products				
The company design processes for minimisation of waste				
Suppliers use environmental packaging (degradable and nonhazardous)				
Suppliers use environmental packaging (degradable and nonhazardous)				
There is Investment recovery (sale) of excess inventories/materials at a regular time interval				
The company sells scrap and used materials at regular intervals				
The company sells excess capital equipment				
The company collects and recycles end-of-life products and materials				
The company have recycles system for used and defective products				

3. SECTION C

SUSTAINABLE SUPPLY CHAIN PERFORMANCE

Please read carefully the following statements and indicate to the best of your knowledge whether the degree to which you agree or disagree with the following statements

Sustainable supply chain performance (SSCP)	Strongly Disagree	Disagree	Agree	Strongly Disagree
This firm's primary supply chain has the ability to deliver zero-defect products to final customers				
This firm's primary supply chain has the ability to deliver value-added services to final customers				
This firm's primary supply chain has the ability to eliminate late, damaged and incomplete orders to final customers				
This firm's primary supply chain has the ability to quickly respond to and solve problems of the final customers				
This firm's primary supply chain has the ability to deliver products precisely on-time to final customers				
This firm's primary supply chain has the ability to deliver precise quantities to final customers				
This firm's primary supply chain has the ability to deliver shipments of variable size on a frequent basis to final customers				
This firm's primary supply chain has the ability to deliver small lot sizes and shipping case sizes to final customers				
This firm's primary supply chain has the ability to minimize total product cost to final customers				
This firm's primary supply chain has the ability to minimize all types of waste throughout the supply chain				
This firm's primary supply chain has the ability to minimize channel safety stock throughout the supply chain				

4. SECTION D

SUPPLY CHAIN CAPABILITY

Please read carefully the following statements and indicate to the best of your knowledge whether the degree to which you agree or disagree with the following statement

Supply chain capability (SCC)	Strongly Disagree	Disagree	Agree	Strongly Disagree
The firm liaisons between purchasing and other functions				
The firm gives detailed purchasing policies and procedures				
The firm makes partnership approach with suppliers				
The firm enhances technical skills of purchasing professionals				
The firm advances the understanding of environmental issues and how they affect supply				

5. SECTION E

SUPPLY CHAIN FLEXIBILITY

Please read carefully the following statements and indicate to the best of your knowledge whether the degree to which you agree or disagree with the following statement

Supply chain flexibility (SCF)	Strongly Disagree	Disagree	Agree	Strongly Disagree
There is a reduction of manufacturing lead-time				
There is a reduction of product development cycle time				
There is an increase in frequency of new product introductions				
There is an increase of level of customization				
There is an adjustment of worldwide delivery capacity/capability				
There is an improvement of level of customer service				
There is an improvement in delivery reliability				
There is an improvement in responsiveness to changing market needs				

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