

FROM LINEAR TO CIRCULAR: HARNESSING SUPPLY CHAIN CAPABILITIES AND CE PRACTICES FOR SUSTAINABLE FOOD SUPPLY CHAINS

ABSTRACT

Purpose: This paper aims to empirically assess the impact of SC Capabilities (agility, collaboration, and traceability), and CE practices on in food supply chains (FSCs).

Design/methodology/approach: To achieve its objectives, this study set out to collect primary data via a self-administered survey from 299 managerial-level employees in the dynamic UK food and drink manufacturing sector. Covariance-based Structural equation modeling (CB-SEM) was used to test the hypotheses.

Findings: The results suggest that supply chain (SC) capabilities particularly collaboration, and traceability play key roles in fostering Circular Economy (CE) practices, which in turn contribute to sustainable performance in food supply chains. However, agility was not found to have a statistically significant influence on CE practices in this study. While SC agility and traceability were positively associated with sustainable supply chain performance (SSCP), SC collaboration did not show a supportive effect on SSCP. Interestingly, CE practices were found to have a statistically significant positive impact on sustainable supply chain performance. Mediation analysis revealed that CE practices significantly and positively mediate the relationships between SC agility, collaboration, traceability, and sustainable supply chain performance, highlighting their critical role in driving sustainable performance across the food supply chain.

Research limitations: The primary limitation of our study is that it utilizes cross-sectional data from a single geographic location and industry.

Practical implications: By strategically harnessing of SC Capabilities (agility, collaboration, and traceability), CE practices supply chain professionals can drive meaningful sustainability improvements throughout their supply chain performance.

Originality/value: The conceptual framework presented in this study offers a novel foundation for enhancing sustainability in supply chains by integrating core supply chain capabilities (agility, collaboration, and traceability) and CE practices.

Key Words: Circular Economy, Circular Economy Practices, SC capabilities, Agility, Collaboration, Traceability, Sustainability, Food supply chains, Sustainable performance.

INTRODUCTION

Supply chain capabilities (SCCs) are fundamental to an organization to effectively manage its entire supply chain by identifying, utilizing, and integrating both internal and external resources and information (Wu et al., 2006). These capabilities are unique to each firm and represent their distinct strengths, making them difficult for competitors to replicate them (Wernerfelt, 1984). The literature distinguishes between ordinary (or operational/static) capabilities and dynamic SC capabilities. Ordinary or operational capabilities determine how a firm produces revenue, whereas dynamic capabilities drive change and improvement (Laaksonen and Peltoniemi, 2018). The objective of dynamic capabilities is to strategically reconfigure a company's resources and operational procedures in order to achieve substantial improvements (Cepeda and Vera, 2007, Aslam et al., 2020). Researchers have suggested that the development of "dynamic capabilities" and the subsequent application of those capabilities can enable firms to identify and reduce vulnerabilities before they occur (Yu et al., 2019, Echefaj, Charkaoui and Cherrafi, 2022). The importance of supply chain capabilities has been emphasized by scholars, who have provided comprehensive lists of both static and dynamic logistics and supply chain capabilities (Defee and Fugate, 2010). This distinction underscores the need for organizations to not only focus on their day-to-day operational capabilities but also to cultivate dynamic capabilities that allow them to adapt and flourish in an ever-changing business environment.

Circular economy (CE) has gained attention as a promising alternative to the conventional linear economic model of "take-make-use," focusing on principles of regeneration, waste reduction, and pollution minimization (Ellen Macarthur Foundation, 2015). This innovative approach to resource utilization offers organizations a fresh perspective on how to create and capture value throughout the product lifecycle. At its core, the circular economy emphasizes the recovery and regeneration of resources once a product has reached the end of its useful life (Mangla et al., 2018, Farooque et al., 2019). The integration of CE practices (CEP) in supply chain management offers compelling prospective in achieving the desired business performance, decreasing the consumption of raw materials, promoting the reuse and closed-loop flow of materials, preventing energy leakages, lowering emissions, preventing pollution, and overall decline of environmental impact (Bai et al., 2020, Lengyel et al., 2021). By adopting CE principles, organizations can create more sustainable supply chains that not only contribute to environmental preservation but also drive economic value, encouraging businesses to rethink their resource utilization strategies for a more sustainable future.

Several researchers have emphasized the integration of Circular Economy (CE) practices for enhancing sustainable supply chain performance (Bai et al., 2020, Del Giudice et al., 2020, Hussain and Malik, 2020, Kumar et al., 2023). By incorporating CE practices, organizations can design products and business models that prioritize durability, repairability, and recyclability, resulting in reduced waste, improved resource efficiency, and a lower environmental footprint. However, only a few studies highlight the critical role of both supply chain capabilities and CE practices in fostering a sustainable food supply chain (Perçin, 2022, Cruz and De Arruda Ignacio, 2024).

Sustainability issues in supply chains have been extensively studied from various perspectives in recent years (Chowdhury, Agarwal and Quaddus, 2019). (Seuring and Müller, 2008) highlight that achieving sustainable supply chain (SCS) performance requires organizations to address the diverse sustainability expectations of stakeholders. Consequently, focal firms are held accountable for the economic, environmental, and social performance of their supply chain partners. Sustainable supply chain performance (SSCP) integrates economic, environmental, and social factors, emphasizing transparency and accountability (Bag, 2023, Rahman et al., 2023). It refers to a supply chain's ability to operate efficiently while minimizing

negative impacts on the environment, society, and economy (Kumar and Goswami, 2019, Bag et al., 2020, Mangla et al., 2020). This involves adopting sustainable practices across sourcing, production, distribution, and disposal (Dubey and Gunasekaran, 2016, Huma, Ahmed Siddiqui and Ahmed, 2023), aiming to balance these factors for long-term viability (Kumar and Goswami, 2019).

This study provides an integrated analysis of supply chain capabilities—agility, collaboration, and traceability—and their role in promoting Circular Economy (CE) practices to drive sustainable supply chain performance in the food industry. It also examines the direct impact of CE practices on the sustainable performance of food supply chains. By exploring these interrelationships, the study aims to offer a comprehensive framework that clarifies how these components work together to improve the sustainability of food supply chains. To achieve this, the study seeks to address the following key questions:

- RQ1. *What is the impact of supply chain capabilities (agility, collaboration, and traceability) on CE practices and sustainable supply chain performance?*
- RQ2. *What is the impact of CE practices on sustainable supply chain performance?*
- RQ3. *Does CE practices play a mediating role between supply chain capabilities (agility, collaboration and traceability) and sustainable supply chain performance?*

This empirical research was carried out on food and drink manufacturing companies in the UK to investigate the relationships mentioned earlier. The research framework that links these elements was grounded in resource-based, resource-dependency and Dynamic capabilities theories, utilizing AMOS SPSS 29 for analysis. The structure of the paper is as follows: Section 2 presents the background of the concepts employed in the study. Section 3 details the hypotheses developed to establish the research framework. Section 4 describes the research methodology. Section 5 discusses the findings, managerial implications, and theoretical contributions of the study. Lastly, Section 6 concludes with the study's overall findings, limitations, and recommendations for future research.

THEORETICAL BACKGROUND

In this section, we outline the theoretical foundation, essential concepts, hypothesis, and the development of the research model. The focus of the study is the impact of SC capabilities (agility, collaboration and traceability) and Circular Economy (CE) practices on sustainable supply chain performance. To support the framework of this research, we crafted our argument on considering the well-known theories Resource base View (RBV), Resource Dependent Theory (RDT) and Dynamic capabilities Theory (DCT). We adhere to the (Nandi et al., 2021b) and (Tashman, 2021) framework, which emphasises the supportive relationship between RBV and RDT in obtaining resources and capabilities. The RBV highlights the significance of an organization's existing and potential resources and capabilities to establish sustainable competitive advantages. RDT stresses the connections of potential resources that businesses could get from their surroundings to build their competitiveness (Nandi et al., 2021b). According to (Helfat et al., 2009), dynamic capabilities are "an organization's ability to proactively generate, expand, or adjust its resource base". Strong dynamic capabilities are crucial to anticipate the needs of current and prospective customers, as well as gather, arrange, and reorganise the necessary resources to develop innovation in response to those needs.

SC Capabilities

As academic interest in supply chain (SC) capabilities has expanded, researchers have developed various categorizations of these capabilities. (Teece, Pisano and Shuen, 1997) introduced the concept of dynamic capabilities to address the lack of focus on developing resources and capabilities in rapidly changing environments. Later, (Winter, 2003) and (Zollo and Winter, 2002) distinguished between dynamic and operational capabilities. Zollo and Winter (2002) specifically pointed out that Teece, Pisano, and Shuen (1997) overlooked the origins of dynamic capabilities. They proposed that dynamic capabilities involve a systematic pattern of activities that enable an organization to evolve and refine its routines over time, improving its performance and adaptability in changing environments.

Research on dynamic capabilities highlights their role in enhancing operational capabilities and ultimately improving company performance (Eisenhardt and Martin, 2000, Zahra, Sapienza and Davidsson, 2006, Teece, 2007). In a similar vein, (Day, 2014) introduced the concept of adaptive capabilities, describing a firm's ability to expand its dynamic capabilities by adopting an outside-in approach, enabling quicker responses to rapidly changing markets.

On the other hand, (Amit and Schoemaker, 1993, Collis, 1994, Bharadwaj, 2000) emphasized that SC capabilities represent an organization's ability to recognize, use, and integrate both internal and external information and resources to support supply chain operations and activities. Furthermore, Morash (2001) identified seven key SC capabilities as core competences: customer service, quality, information systems support, distribution flexibility, low logistics costs, productivity, and delivery speed. Wu et al. (2006) defined SC capabilities as a second-order construct with four critical components: supply chain responsiveness, coordination, information sharing, and interfirm activity integration. Defee (2010) proposed a framework highlighting the importance of both operational capabilities (efficiency, cost control) and dynamic capabilities (adaptability, innovation, responsiveness). The study advocates for a holistic approach to supply chain management, emphasizing adaptability, innovation, and strategic alignment to navigate a rapidly changing business environment.

CE Practices

Circular Economy Practices (CEP) are commonly framed using various "R" models, each expanding upon the fundamental principles of sustainability and resource efficiency. The most basic of these is the 3R model, which **includes reduce, reuse, and recycle** (Cui et al., 2024). This model focuses on minimizing waste by reducing resource consumption, reusing products or materials to extend their life cycle, and recycling materials to prevent them from becoming waste after their initial use. Building upon the 3R model, the **4R framework** (reduce, reuse, recycle, and recover) (Gebhardt, Spieske and Birkel, 2022) introduces an additional element of **recovery**, which involves reclaiming energy or materials from products that can no longer be reused or recycled. This step helps to optimize the value of products and materials, reducing the need for raw material extraction and minimizing environmental impact. Further extending these concepts, the **9R framework** (Potting et al., 2017) represents an even more advanced approach to Circular Economy practices. It includes a broader range of strategies, such as **refuse, repair, remanufacture, refurbish, rethink, and repurpose**, alongside the core principles of reducing, reusing, recycling, and recovering. This comprehensive framework encourages businesses and industries to consider multiple stages in the life cycle of products, from design to disposal, with an emphasis on creating closed-loop systems that promote sustainable practices across all stages of production, consumption, and post-consumption. Each of these frameworks contributes to a more sustainable approach by encouraging businesses to rethink traditional linear models of production and consumption, promoting the efficient use

of resources, minimizing waste, and fostering long-term environmental sustainability. The progression from the 3R to the 9R model represents an increasing complexity and sophistication in implementing Circular Economy practices, offering more tools for industries to adopt sustainable supply chain models.

Early Circular Economy (CE) measures at the organizational level, introduced by (Zhu, Geng and Lai, 2010), provided the foundational framework for future research in the field. Govindan & Hasanagic (2018) developed a comprehensive CE framework that categorized practices into six clusters: governance, economic initiatives, cleaner production, product development, management support, and knowledge. (Edwin Cheng et al., 2022) categorized CE practices into management support, eco-design, and investment recovery. This framework was later adopted and expanded by researchers such as Riggs et al. (2023). Additionally, (Tseng et al., 2021) introduced a detailed scale to measure CE practices, incorporating strategies such as waste-to-input transformation, resource sharing, energy conservation, and sourcing from the circular economy to create value within supply chains. These studies collectively highlight the evolving and multifaceted nature of CE practices, emphasizing their critical role in fostering sustainable supply chain ecosystems.

Sustainable Supply Chain Performance

The concept of sustainable performance (SP) is commonly understood through a 'three-pillar' framework, which encompasses economic, environmental, and social dimensions, as described by the triple bottom line (Purvis, Mao and Robinson, 2019). Economic performance focuses on maximizing the firm's economic value, typically reflected in its profits or financial outcomes (Andersson et al., 2022). Environmental performance highlights the positive environmental impacts of the firm's operations while aiming to minimize negative effects in terms of resources used and waste generated (Martínez-Falcó et al., 2024). Social performance refers to the firm's initiatives that benefit human capital and society, such as community or employee welfare and health (Nursimloo, Ramdhony and Mooneeapen, 2020). The sustainable performance of a supply chain refers to the outcomes achieved through the implementation of sustainable development practices (Lebas, 1995). This concept emphasizes that the general effectiveness of a supply chain should be evaluated not only in terms of traditional metrics such as cost and efficiency but also considering its sustainability impacts. Mishra et al., (2018) argued that the assessment of supply chain performance has evolved beyond the conventional metrics of efficiency, effectiveness, and economy. Govindan, Khodaverdi and Jafarian (2013) introduced an innovative approach to assessing supply chain sustainability performance using a fuzzy multi-criteria methodology. Their study focused on assessing performance from the perspective of the triple bottom line (TBL) framework, that encompasses the social, economic, and environmental dimensions of business operations. (Slaper and Hall, 2011) defined the Triple Bottom Line (TBL) as an expanded accounting framework that goes beyond traditional financial measures to include social and environmental dimensions of performance.

According to (Carter and Rogers, 2008), sustainable supply chain performance requires balancing the triple bottom line economic, environmental, and social factors to create long-term value. The adoption of sustainable practices can lead to increased operational efficiency, reduced waste, and improved brand reputation, thereby driving competitive advantage (Seuring & Müller, 2008). Furthermore, studies have shown that sustainability in supply chains is closely linked to better financial performance and innovation (Teece, 2007). As organizations face increasing pressure to address environmental and social issues, sustainable supply chain performance has become a key driver of corporate success and resilience (Srivastava, 2007).

DEVELOPMENT OF HYPOTHESES AND RESEARCH MODEL

SC Capabilities (Agility, Collaboration, and Traceability) and CE Practices

The researcher conceptualizes supply chain (SC) capabilities as a set of distinct first-order constructs. This approach identifies agility, collaboration, and traceability as specific dimensions of SC capabilities, each representing a critical aspect of supply chain competency that can be individually measured and analysed. Each dimension reflects the ability to perform cross-functional and interorganizational activities vital for effective supply chain management. Moreover, they capture the dynamic nature of supply chains, enabling organizations to absorb knowledge, technology and adapt to evolving environmental challenges.

The Circular Economy (CE) model transforms linear resource use into a closed-loop system, focusing on "reduce, reuse, recycle," with actions like take, make, distribute, use, and recover (Ormazabal et al., 2016). Integration of CE into SCM has the potential to yield benefits from a sustainability point of view (Genovese et al., 2017, Nasiri et al., 2018). Consequently, there is a growing enthusiasm in supply chain management for CE (Govindan and Hasanagic, 2018, Kazancoglu, Kazancoglu and Sagnak, 2018, Liu et al., 2018, Howard, Hopkinson and Miemczyk, 2019). Nevertheless, Research in SCM is still in its early stages regarding how to improve supply chain theories and methods to achieve the vision and potential of a CE (Farooque et al., 2019). In current study, researcher evaluate how supply chain capabilities, including supply chain agility, collaboration and traceability can facilitate the incorporation of CE thinking in SCM.

H1: SC capabilities (agility, collaboration, and traceability) have a direct and positive impact on CE Practices

Agile supply chains can swiftly respond to changes in market demands, regulations, or consumer preferences (Gligor et al., 2020). This adaptability enables organizations to rapidly adopt circular economy practices, such as incorporating recycled materials, implementing remanufacturing processes, or launching product-as-a-service models (Nandi et al., 2021a). In a circular economy, effective reverse logistics is crucial for collecting, refurbishing, and recycling used products and materials (Do et al., 2021). An agile supply chain optimizes reverse logistics processes (Soosay and Hyland, 2015, Wanganoo, 2020), ensuring seamless flow and handling of end-of-life goods back into the circular system (Sadeghi et al., 2023). Agility is required in CE for the identification, production, and delivery of by-products formerly considered as waste for new applications and customers (Nandi et al., 2021b).

H1a: Agility has a direct and positive impact on CE Practices

Collaboration between product designers, manufacturers, and suppliers allows for the incorporation of circular design principles right from the beginning (Calicchio Berardi and Peregrino de Brito, 2021). Collaborative efforts can focus on creating products that are easily repairable, upgradable, and recyclable, contributing to a circular product lifecycle (Bloise, 2020). Collaboration streamlines close loop processes, making it easier to handle product returns, repairs, and recycling. By working together, supply chain partners can efficiently manage the flow of used products and materials back into the circular system. (Hussain and Malik, 2020) also argued that the expansion of upstream and downstream collaborative interactions outside the traditional industrial limits of a supply chain enables a shift to circular economy.

H1b: Collaboration has a direct and positive impact on CE Practices

Traceable system capable of identifying each unit produced and supplied from the farm to the fork (Thakur., 2009). A traceability system allows for the synchronisation of information in circular supply chains, which in turn benefits all stakeholders engaged in the supply chain by allowing for better, more well-informed decision-making (Centobelli et al., 2021, Xu et al., 2021). Traceability systems that track the movement of materials both upstream and downstream in the supply chain, collect items in manageable quantities, and share information with consumers and supply chain stakeholders are crucial for effectively implementing Circular Economy (CE) practices in supply chain management (Anastasiadis et al., 2022). According to the literature, traceability systems contribute to the sustainability of the agri-food SC (Epelbaum and Martinez, 2014, Garcia-Torres et al., 2019) and are crucial for the implementation of CE practises (Garcia-Torres et al., 2019, Anastasiadis et al., 2022).

H1c: Traceability has a direct and positive impact on CE Practices

SC Capabilities (Agility, Collaboration, And Traceability) and Sustainable Supply Chain Performance (SSCP)

Sustainable supply chains (SSC) integrate economic, environmental, and social factors into their operations, ensuring transparency and accountability to all stakeholders (Bag and Rahman, 2023, Piprani et al., 2023). The concept of sustainable supply chain performance (SSCP) refers to a supply chain's ability to operate efficiently while minimizing negative impacts on the environment, society, and economy (Kumar, Subramanian and Maria Arputham, 2018, Mangla et al., 2020, Kazancoglu et al., 2022). This involves incorporating sustainable practices across sourcing, production, distribution, and disposal (Dubey and Gunasekaran, 2016, Shahid et al., 2020), aiming to balance economic, social, and environmental factors for long-term viability (Singh, 2024). Firms need capabilities to combine sets of interdependent resources on a regular basis to establish performance-enhancing patterns if they want to achieve sustainable performance (Morash, 2001, Sirmon et al., 2011, Schmidt and Keil, 2013).

H2: SC capabilities (agility, collaboration, and traceability) have a direct and positive impact on Sustainable Supply Chain Performance

Businesses require supply chain agility to respond rapidly and effectively to the sustainable demands of their industry (Al Humdan et al., 2020; Geyi et al., 2020; Nath and Agrawal, 2020). According to (Ciccullo et al., 2018), supply chain agility and SSCM can work together to form a complementary and synergistic new paradigm. Additionally, the adoption of SSCM can be facilitated by cultivating supply chain agility practises, which in turn can assist in the evolution and long-term viability of sustainability initiatives and practises (Nath and Agrawal, 2020). (Geyi et al., 2020) argue that agile capabilities are essential for optimising the results of implementing sustainable practises. (Cantele et al., 2023) stated that high sustainability performance can be accomplished through various approaches, involving varying degrees of supply chain agility and values for each proposed sustainability endeavour.

H2a: Agility has a direct and positive impact on sustainable supply chain performance

For businesses to meet their economic, social, and environmental sustainability goals, supply chain collaboration has emerged as a key factor (Chen et al., 2017). According to (Soylu et al.,

2006) supply chain collaboration is a common approach for businesses to share information, forge partnerships for enhanced performance, and reduce costs and inventory. The aim of collaboration in a supply chain is to enhance a company's competitive advantage (Soylu et al., 2006; Cao and Zhang, 2011). Cao et al., (2010) stated that supply chain collaboration can help reduce risks such as conflicts and uncertainty by strengthening relationships between all parties involved, and that it can also be seen from a learning and knowledge perspective, wherein mutual information inception enhances innovation and expands resources. Supply chain collaboration helps organisations in having complete knowledge across all SSCM dimensions. Cao and Zhang (2011) highlighted the beneficial effects of supply chain collaboration on financial metrics and (Chin, Tat and Sulaiman, 2015) investigated the effects of collaboration on sustainable supply chain performances from the viewpoint of an environmental approach. Supply chain collaboration and SSCP have been found to be positively correlated by several studies (Mehdikhani and Valmohammadi, 2019, Shahid et al., 2020, Billah et al., 2023).

H2b: Collaboration has a direct and positive impact on sustainable supply chain performance

Traceability has been regarded as a "good practise" for risk management (Lupien, 2005), a competitive advantage (Canavari et al., 2010) a unique resource embedded in firms' routines (Brofman Epelbaum and Martinez, 2014), and valuable knowledge resources related to value (Engelseth, Wongthatsanekorn and Charoensiriwath, 2014) for businesses, serving as a means of product safety monitoring. The necessity of traceability has become essential to enhance the vulnerabilities present in various aspects of business operations (Dandage, Badia-Melis and Ruiz-García, 2017). (Brofman Epelbaum and Martinez, 2014, Zhou, Pullman and Xu, 2021) has investigated the relationship between supply chain traceability and sustainable supply chain performance. Based on the reviewed literature, we hypothesize that supply chain traceability is an essential capability for sustainable supply chain performance, as it enhances transparency and accountability (Onu, Mbohwa and Pradhan, 2024), mitigates risks (Mabe Parenreng et al., 2016) fosters collaboration and innovation among stakeholders (Garcia-Torres et al., 2019, 2022) and ultimately contributes to greater efficiency and competitiveness in supply chain operations (Zhou, Pullman and Xu, 2021).

H2c: Traceability has a direct and positive impact on sustainable supply chain Performance

Effect of CE Practices on Sustainable Supply Chain Performance

The circular economy (CE) is an economic model that focuses on reusing and recycling materials instead of discarding them, promoting resource efficiency through regeneration and restoration (de Sousa Jabbour et al., 2018; Sauvé et al., 2016). It requires innovation in both products and processes to shift away from the traditional linear model (Preston, 2012; Adams et al., 2017). CE practices reduce dependence on virgin materials, minimize energy losses, lower emissions, and promote recycling and closed-loop material flows (Bai et al., 2020; Cheng et al., 2022). As companies increasingly adopt CE, they contribute to solving major environmental challenges such as climate change, waste, and biodiversity loss (Bag & Rahman, 2023). CE provides businesses with a framework for sustainability, helping them adopt best practices (Genovese et al., 2017). Studies also show that CE practices significantly enhance sustainability performance in supply chains, particularly in sectors like food (Le, Behl & Pereira, 2022).

As per the aforementioned arguments, the following hypothesis is proposed.

H3: CE Practices has a direct and positive impact on sustainable supply chain performance

Mediating Effect of CE Practices Between SC Capabilities (Agility, Collaboration, and Traceability) and Sustainable Supply Chain Performance

Circular Economy (CE) practices aim to replace traditional linear production models with circular ones through steps like reducing, reusing, and recycling (Schroeder et al., 2019). Frameworks like 3R, 4R, and 9R guide these practices (Cui et al., 2024; Gebhardt et al., 2022; Potting et al., 2017). Agility helps firms adapt CE practices, while collaboration fosters circular solutions (Castro-Lopez et al., 2023). Traceability ensures the integrity of circular processes by monitoring materials throughout the supply chain (Govindan & Hasanagic, 2018). CEP not only delivers economic benefits like cost reduction and new revenue streams (Rosa et al., 2019) but also enhances social welfare by promoting collaboration, especially among SMEs (Howard et al., 2022). These findings suggest that CE practices mediate the relationship between supply chain capabilities (agility, collaboration, and traceability) and sustainable supply chain performance.

Based on this, we hypothesize the following:

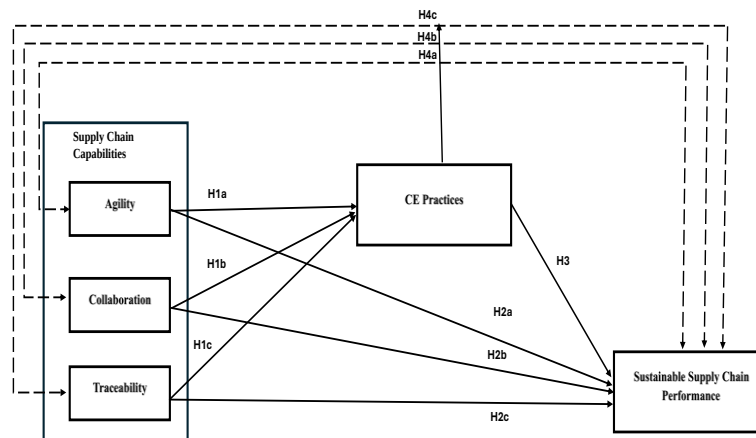
H4: CE Practices mediates the relationship between SC capabilities (agility, collaboration, and traceability) and Sustainable Supply Chain Performance

H4a: CE Practices mediates the relationship between agility, and sustainable supply chain performance

H4b: CE Practices mediates the relationship between collaboration, and sustainable supply chain performance

H4c: CE Practices mediates the relationship between traceability, and sustainable supply chain performance

Figure 1: Proposed Model



METHODS

Sampling and Data Collection

Demographic Questions	No.	Percent
Firm Profile		
Annual Revenue		
50-100 million £	131	44%
100-250 million £	100	33%
250-500 million £	63	21%
More than 500 million £	5	2%
Respondent Profile		
Designation		
Supply Chain Manager	72	24%
Distribution/Warehouse Manager	59	20%
Logistics/Transport/Freight Manager	47	16%
IT Manager	33	11%
Purchase Manager	26	9%
Project/Production Manager	28	9%
CEO/Director/President	22	7%
Owner/Partner	12	4%
Years in the Company		
1-5	59	20%
6-8	67	22%
9-10	32	11%
More than 10	141	47%
Gender		
Male	240	80%
Female	59	20%

The study focused on the UK food and drink manufacturing sector. The study surveyed 750 employees at the managerial level and above from UK food and drink manufacturers. A total of 315 responses were initially received, resulting in a 42% response rate. After excluding 16 incomplete responses, the final sample size was 299, bringing the revised response rate to 39.87%. The survey was conducted between October 2022 and February 2023. To analyse the data, the study employed Covariance-Based Structural Equation Modelling (CB-SEM), which is well-suited for handling models with complex structural relationships between variables.

Measures/Respondent Information

The current study utilized a self-administered questionnaire survey to achieve its research objectives. To align with the study's goals, the researcher adapted scales used in previous studies. All the measurement items in this research were derived from existing literature. In order to improve clarity and understanding, two experts were consulted, and a pretest was conducted with 30 managers. This led to revisions of certain unclear items. The final measurements were assessed using a seven-point Likert scale. The questionnaire included items to evaluate supply chain agility (adapted from (Brusset, 2016; Gligor et al., 2019; Baah et al., 2023), supply chain collaboration (adapted from (Cao et al., 2010; Nyaga, Whipple and Lynch, 2010; Baah et al., 2022), supply chain traceability (adapted from (Bowen et al., 2001; Skilton and Robinson, 2009; Dabbene, Gay and Tortia, 2014; Wowak, Craighead and Ketchen, 2016; Cousins et al., 2019), CE practices (8 items, adapted from (Le, Behl and Pereira, 2022); (Riggs et al., 2023), and sustainable supply chain practices, (adapted from (Kumar et al., 2019; Bag et al., 2020; Kumar and Kumar Singh, 2021).

It is important to note that the questionnaire used in our research consisted of two sections: Section 1 contained demographic questions, as presented in Table 1; Section 2 dealt with items derived from the scales.

Table 1: Demographic Characteristics

Demographic Questions	No.	Percent
Firm Profile		
Annual Revenue		
50-100 million £	131	44%
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Owner/Partner	12	4%
Years in the Company		

1-5	59	20%
6-8	67	22%
9-10	32	11%
More than 10	141	47%
Gender		
Male	240	80%
Female	59	20%

ANALYSIS AND RESULTS

Harman's one-factor test was used to check for common method bias (CMB) before testing the proposed research model (Hair, Black and Babin, 2010). The single factor accounted for 29.19% of the variance, which is below the 50% threshold, suggesting no common method bias was present. To assess multi-collinearity among the research model constructs, the Variance Inflation Factor (VIF) was calculated. All VIF values were below the recommended threshold of 10, ranging from 1.28 to 1.97, indicating that multicollinearity was not an issue.

Reliability of the constructs was evaluated using Cronbach's alpha and Composite Reliability (C.R). The results revealed that both Cronbach's alpha and C.R values exceeded 0.7, confirming the reliability of the scales in the model (see Table 2). Convergent validity was assessed by examining the average variance extracted (AVE) values (see Table 2). The results indicate that all AVE values exceed 0.5, confirming the absence of convergent validity issues (Belhadi et al., 2020).

Table 2: Reliability and Validity Tests Results

Constructs	Cronbach's Alpha	Composite Reliability	Average Variance Extracted (AVE)
Agility (Ag)	0.770	0.812	0.519
Collaboration (Col)	0.921	0.924	0.710
Traceability (Tr)	0.933	0.927	0.718
Circular Economy Practices (CEP)	0.896	0.898	0.595
Sustainable Supply Chain Performance (SSCP)	0.913	0.916	0.686

Discriminant validity was evaluated using both the Fornell and Larcker criterion and the Heterotrait-Monotrait ratio of correlations (HTMT) analysis. According to (Hair, Black and Babin, 2010) discriminant validity is established when the square root of the AVE was greater than the inter-correlation values between the constructs, a criterion set by Fornell -Larcker. The values in Table 3 confirm that there are no issues with discriminant validity in the study.

Table 3: Fornell-Larcker Criterion

Constructs	Agility (Ag)	Collaboration (Col)	Traceability (Tr)	Circular Economy Practices (CEP)	Sustainable Supply Chain Performance (SSCP)
Agility (Ag)	0.72				
Collaboration (Col)	0.20	0.84			
Traceability (Tr)	0.26	0.17	0.85		
Circular Economy Practices (CEP)	0.20	0.19	0.59	0.77	
Sustainable Supply Chain Performance (SSCP)	0.38	0.24	0.46	0.42	0.83

HTMT values were assessed to ensure they are below the recommended threshold of 0.85 for discriminant validity (Hair, Black and Babin, 2010). As shown in Table 4, the highest observed HTMT value was 0.57, confirming the absence of any discriminant validity concerns.

Table 4: Heterotrait - Monotrait (HTMT) Ratio Test

Constructs	Agility (Ag)	Collaboration (Col)	Traceability (Tr)	Circular Economy Practices (CEP)	Sustainable Supply Chain Performance (SSCP)
Agility (Ag)					
Collaboration (Col)	0.47				
Traceability (Tr)	0.53	0.17			
Circular Economy Practices (CEP)	0.20	0.19	0.57		
Sustainable Supply Chain Performance (SSCP)	0.38	0.24	0.45	0.41	

Structural Model Findings

The structural model was analysed for path significance and explanatory power using bootstrapping techniques, yielding some intriguing results are summarized in Table 5. The results indicated a partial positive relationship between SC capabilities (agility, collaboration and traceability) and CE Practices. **H1a (Agility → CE Practices):** The relationship between agility and CE practices was found to be negative ($b = -0.002$) with a t-value of -0.04 and a p-value of 0.97. This suggests that agility does not significantly contribute to the adoption of CE practices, as the relationship is very weak and statistically insignificant ($p > 0.05$). **H1b (Collaboration → CE Practices):** A positive relationship was observed between collaboration and CE practices ($b = 0.094$), with a t-value of 1.77 and a p-value of less than 0.01. This indicates that collaboration has a significant positive impact on the adoption of CE practices, with the relationship being statistically significant ($p < 0.05$). **H1c (Traceability → CE Practices):** The relationship between traceability and CE practices was strong and positive ($b = 0.604$), with a t-value of 1.82 and a p-value of less than 0.001. This indicates that traceability

is a significant and highly influential factor in the adoption of CE practices, with a strong, statistically significant positive effect ($p < 0.001$).

The results partially supported the H2 hypothesis, which examined the relationship between supply chain (SC) capabilities (agility, collaboration, and traceability) and sustainable supply chain performance (SSCP). **H2a (Agility $\rightarrow$ SSCP)**: The relationship between agility and SSCP was supported with a positive coefficient ($b = 0.161$), a t-value of 2.87, and a p-value of less than 0.001. This suggests that agility has a significant positive effect on sustainable supply chain performance, with the relationship being statistically significant ($p < 0.001$). **H2b (Collaboration $\rightarrow$ SSCP)**: The relationship between collaboration and SSCP was not supported. The coefficient was negative ($b = -0.056$), with a t-value of -1.06 and a p-value of 0.29, indicating that collaboration does not have a statistically significant effect on sustainable supply chain performance. Since the p-value is greater than 0.05, the result is not considered significant. **H2c (Traceability $\rightarrow$ SSCP)**: The relationship between traceability and SSCP was supported, with a positive coefficient ($b = 0.225$), a t-value of 3.89, and a p-value of less than 0.001. This suggests that traceability has a strong and significant positive effect on sustainable supply chain performance, with the relationship being highly statistically significant ($p < 0.001$).

The results strongly supported the **H3 (CEP $\rightarrow$ SSCP) hypothesis**, which examined the relationship between Circular Economy Practices (CEP) and Sustainable Supply Chain Performance (SSCP). The analysis demonstrated a robust positive relationship between the two variables, with a coefficient of $b = 0.172$, a t-value of 3.04, and a p-value of less than 0.001.

Table 5: Structural model findings (direct effects)

Hypothesis	Relationship	Standardised Co-efficient	t-Value	p-Value	Result
H1a	Ag $\rightarrow$ CEP	-0.002	-0.04	0.97	Not Supported
H1b	Col $\rightarrow$ CEP	0.094	1.77	**	Supported
H1c	Tr $\rightarrow$ CEP	0.604	1.82	***	Supported
H2a	Ag $\rightarrow$ SSCP	0.161	2.87	***	Supported
H2b	Col $\rightarrow$ SSCP	-0.056	-1.06	0.29	Not Supported
H2c	Tr $\rightarrow$ SSCP	0.225	3.89	***	Supported
H3	CEP $\rightarrow$ SSCP	0.172	3.04	***	Supported

Mediation

The study utilized the bootstrapping approach to thoroughly examine the indirect effects between supply chain (SC) capabilities (agility, collaboration, and traceability) and Circular Economy Practices (CEP), ultimately linking them to sustainable supply chain performance (SSCP). Bootstrapping is a robust statistical method used to assess indirect effects by repeatedly resampling the data to estimate the precision of the effects (Hayes et al., 2013).

The findings revealed a statistically significant indirect effect, which supported **Hypothesis 4**. This means that Circular Economy Practices (CEP) act as a mediator in the relationship between SC capabilities (agility, collaboration, traceability) and sustainable supply chain

performance. In other words, SC capabilities indirectly influence SSCP through the implementation of CE practices.

The mediation analysis further showed that CEP effectively mediates the relationships as follows:

Table 6: Summary of Mediation Effect

Hypothesis	Relationship	Direct Effect	Indirect Effect	Confidence Interval		P-Value	t-Value	Result
				Lower Bound	Upper Bound			
H4a	Ag → CEP → SSCP	0.39	0.093	0.045	0.153	***	6.67	Supported
H4b	Col → CEP → SSCP	0.56	0.030	0.041	0.148	***	7.81	Supported
H4c	Tr → CEP → SSCP	0.319	0.241	0.083	0.302	***	3.67	Supported

Agility → SSCP (H4a): the indirect effect was significant, with a coefficient of $b = 0.093$, a t-value of 6.67, and a p-value less than 0.001. This suggests that CE practices mediate the positive relationship between supply chain agility and sustainable supply chain performance. **Collaboration → SSCP (H4b):** the indirect effect was also significant, with a coefficient of $b = 0.030$, a t-value of 7.81, and a p-value less than 0.001. This indicates that collaboration, through the adoption of CE practices, plays a significant role in enhancing sustainable supply chain performance. **Traceability → SSCP (H4c):** the indirect effect was substantial, with a coefficient of $b = 0.241$, a t-value of 3.67, and a p-value less than 0.001. This shows that traceability has a notable and significant indirect impact on +sustainable supply chain performance via CE practices.

DISCUSSION

This section examines the results of our research in relation to the previously established research questions (RQs).

RQ1. What is the impact of supply chain capabilities (agility, collaboration, and traceability) on CE practices and sustainable supply chain performance?

(a). Effect of SC Capabilities (agility, collaboration, and traceability) on CE Practices

This research found a negative and insignificant relationship between agility and circular economy (CE) practices ($b = -0.002$, $p = 0.97$), contradicting previous studies that emphasize agility's role in enabling the transition to a circular economy (Nandi et al., 2021a; Bag, 2023; Javeed & Akram, 2024). Despite this, collaboration showed a significant positive correlation with CE practices ($b = 0.094$, $p < 0.01$), supporting the view that collaboration among supply chain stakeholders is crucial for adopting and improving CE practices (Calicchio Berardi & Peregrino de Brito, 2021; Bloise, 2020; Leising et al., 2018).

Additionally, traceability was positively linked with CE practices ($b=0.361$, $p<0.001$), aligning with findings that traceability is essential for enabling CE, particularly in reducing food waste and supporting closed-loop systems (Anastasiadis et al., 2022; Santana & Ribeiro, 2022; Centobelli et al., 2022). This study reinforces that traceability provides transparency and accountability, vital for facilitating circular economy practices across supply chains.

(b). Effect of SC Capabilities (agility, collaboration, and traceability) on Sustainable Supply Chain Performance

This study found a positive association between agility and sustainable supply chain performance ($b=0.161$, $p<0.001$), supporting previous research that agile supply chains can better integrate sustainable practices and improve social and environmental outcomes (Geyi et al., 2020; Alfalla-Luque et al., 2023). Agility enables quick responses to market changes and enhances sustainability through better resource utilization (Blome et al., 2013; Suifan et al., 2020).

The study also revealed that supply chain collaboration (SCC) has a negative and insignificant impact on sustainable supply chain performance ($b=-0.056$, $p=0.29$), suggesting that collaboration, while beneficial, can also introduce challenges (Cao & Zhang, 2011; Vachon & Klassen, 2008).

Finally, traceability was found to have a positive and significant impact on sustainable supply chain performance ($b=0.225$, $p<0.001$), aligning with studies that highlight traceability's role in enhancing transparency, accountability, and sustainability (Ma et al., 2023; Zhou et al., 2022; Marconi et al., 2017). Traceability systems improve sustainability by tracking products from origin to consumer and identifying inefficiencies (Koberg & Longoni, 2019).

RQ2. What is the impact of CE practices on sustainable supply chain performance?

(a). Effect of CE practices on sustainable supply chain performance

The analysis reveals that Circular Economy (CE) practices positively impact sustainable supply chain performance ($b=0.172$, $p<0.001$), supporting H3. This aligns with studies by Malhotra (2023) and Karmaker et al. (2023), which show that CE practices enhance supply chain performance, especially through Industry 4.0 technologies and green supply chain management. CE practices also improve production efficiency and reduce environmental costs (Tang et al., 2022; Khan et al., 2021). Additionally, they promote global cooperation for sustainability (Arsawan et al., 2024). This research, focused on the food and drink sector, adds empirical evidence that adopting CE practices significantly improves the sustainability performance of supply chains across economic, environmental, and social dimensions.

RQ3. Does CE practices play a mediating role between supply chain capabilities (agility, collaboration and traceability) and sustainable supply chain performance?

The mediation analysis shows that CE practices significantly mediate the relationship between SC capabilities (agility, collaboration, and traceability) and sustainable supply chain performance ($b=0.093$, $p < 0.001$; $b=0.030$, $p < 0.001$; $b=0.241$, $p < 0.001$). Studies by Genovese et al. (2017) and Franco (2017) support this, highlighting that CE practices enhance agility, collaboration, and traceability, all crucial for sustainability. Govindan and

Hasanagic (2018) and Riggs et al. (2023) also emphasize the role of traceability and CE practices in improving supply chain sustainability. This study underscores that integrating SC capabilities with CE practices is key to achieving sustainable performance in food supply chains.

Theoretical and Practical Implications

Previous research has examined various supply chain capabilities, but this study focuses on three key capabilities (agility, collaboration, and traceability) in the context of food supply chains. It introduces a measurement model that integrates these SC capabilities with circular economy (CE) practices to enhance sustainable supply chain performance.

This research contributes to the academic field by providing empirical evidence that strengthens the proposed framework, reinforcing its relevance in supply chain management. It also explores the mediating role of CE practices, offering insights into how they influence the relationship between supply chain capabilities and sustainable performance.

Practically, the study provides a model combining SC capabilities with CE practices, guiding supply chain managers in building more sustainable food supply chains. By applying these insights, professionals can leverage these capabilities to drive meaningful sustainability improvements.

CONCLUSION

In today's rapidly evolving business environment, where sustainability is not just a trend but a strategic necessity, this study explores the complex interplay of factors that drive sustainable supply chain performance. Specifically, it examines the synergistic relationship between supply chain capabilities (agility, collaboration, and traceability) and circular economy (CE) practices, alongside their collective impact on achieving sustainable supply chain outcomes. Additionally, the study investigates the mediating role of CE practices in the relationship between these supply chain capabilities (agility, collaboration, and traceability) and sustainable supply chain performance.

The study collected primary data through a self-administered survey from 299 managerial-level employees within the dynamic and crucial UK food and drink manufacturing sector. The analysis of this data produced insightful findings. Notably, the empirical evidence revealed a significant positive relationship between SC capabilities, particularly collaboration and traceability, and CE practices. However, no statistically significant link was found between agility and CE practices. Similarly, the direct influence of collaboration on sustainable supply chain performance (SSCP) did not reach statistical significance in this study. Despite this, the study established a quantitative framework for assessing sustainable supply chain performance, with CE practices demonstrating a significant positive impact on sustainable supply chain performance (SSCP).

Furthermore, the study revealed that CE practices play a crucial mediating role, positively and significantly influencing the relationship between agility, collaboration, traceability, and sustainable supply chain performance.

This study is distinctive in its exploration of the relationships among SC capabilities (agility, collaboration, and traceability), CE practices, and sustainable supply chain performance, specifically within the UK food and drink manufacturing industry. The conceptual framework proposed in this research offers a novel foundation for future studies, encouraging scholars to build upon it by further investigating the integration of SC capabilities and CE practices to enhance sustainable supply chain performance.

Limitations and Future Scope of Research

While this research provides valuable insights, it has certain limitations. The reliance on a survey methodology limits the depth of data captured, and the focus on UK food and drink manufacturing firms may restrict the generalizability to other industries or regions. Additionally, the cross-sectional design only captures data at one point in time, while supply chain capabilities and CE practices are dynamic and evolve over time. A longitudinal approach would be more suitable for understanding these factors' long-term impacts. The sample also focused on high-level employees, potentially overlooking the perspectives of lower-level staff.

Despite these limitations, the study paves the way for future research, exploring broader supply chain capabilities and using longitudinal designs to better capture the evolving nature of sustainable supply chain performance.

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