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Circular Economy Adoption in Supply Chains: Drivers, Barriers, and Performance Outcomes

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***Abstract*-- The present study aims to conduct a literature synthesis to understand the factors, challenges, and outcomes of adopting circular economy practices in supply chains. Circular supply chains have been conceptualized as regenerative systems that incorporate reuse, repair, remanufacturing, recycling, and other forms of closed-loop material flows into the supply chain's fundamental operations. Based on the literature review, the drivers of adopting circular economy practices in supply chains have been identified as regulatory push factors, market pull factors, innovation push factors, corporate social responsibility, and cost reduction. On the other hand, challenges to the adoption of circular economy practices in supply chains include a lack of awareness, financial constraints, limited infrastructure, supply chain complexity, and the need to manage change, especially in small and medium-sized enterprises.**

The present study also aims to explore the outcomes of adopting circular economy practices in supply chains, including effects on resource productivity, greenhouse gas reduction, stakeholder engagement, and competitiveness. A comparative analysis of linear and circular supply chain systems accounts for the dynamic nature of flow structures in linear supply chains. A brief overview of existing circular supply chain systems in America, Asia, and Africa has been provided to understand variations in policy support, infrastructure, and industry development across regions.

***Keywords*-- Circular Economy; Circular Supply Chains; Sustainable Supply Chain Management; Closed-Loop Systems; Industry 4.0; SME Barriers; Sustainability Performance; Competitive Advantage.**

I. Introduction

The circular economy has gained significant attention as a transformational approach to sustainable development. It aims to redefine growth by focusing on positive society-wide benefits, decoupling economic activity from the consumption of finite resources, and redesigning material life cycles to be restorative and regenerative by design. These principles resonate well with supply chain management and logistics, which are already concerned with the flow and availability of materials throughout the production and consumption system.

Circular modes of production, known as the circular economy, are welcomed in political and business circles to overcome the shortcomings of traditional linear operating models. Academic literature on the circular economy is nascent; however, little attention is given to the supply chain management implications (Hazen, et al., 2021) despite the relevance of supply chain innovation to a more resource-efficient, circular economy.

Based on a review of the literature, the following propositions concerning implications for the development of what is termed 'circular supply chains', defined here as the embodiment of circular economy principles within supply chain management, are presented. These propositions are based on the following arguments: a) a shift from product ownership to leasing and access in supply chain relationships; b) the relevance of structural flexibility and start-ups in regional/local loops; c) open and closed material loops in technical and biological cycles; d) closer collaboration within and beyond immediate industry boundaries; and e) public and private procurement in the service industry as a lever for the scaling up of circular business models. The circular economy principles are discussed in terms of supply chain challenges and limitations, and a further research agenda are identified (De Angelis et al., 2018).

II. Understanding Circular Economy

The circular economy (CE) model is fundamentally built on the vital introduction of sustainable production–consumption patterns that prioritize environmental integrity. A successful and well-implemented circular economy (CE) model not only significantly reduces the need for finite raw materials but also plays a vital role in maintaining ecological balance, thereby ensuring a sustainable, long-lasting system for the betterment of future generations (Skalli et al., 2025). In the circular economy model, resources are extracted with extreme care and caution, ensuring they are utilized to their full potential within the economy. This allows these resources to be made available for future use by others as well.

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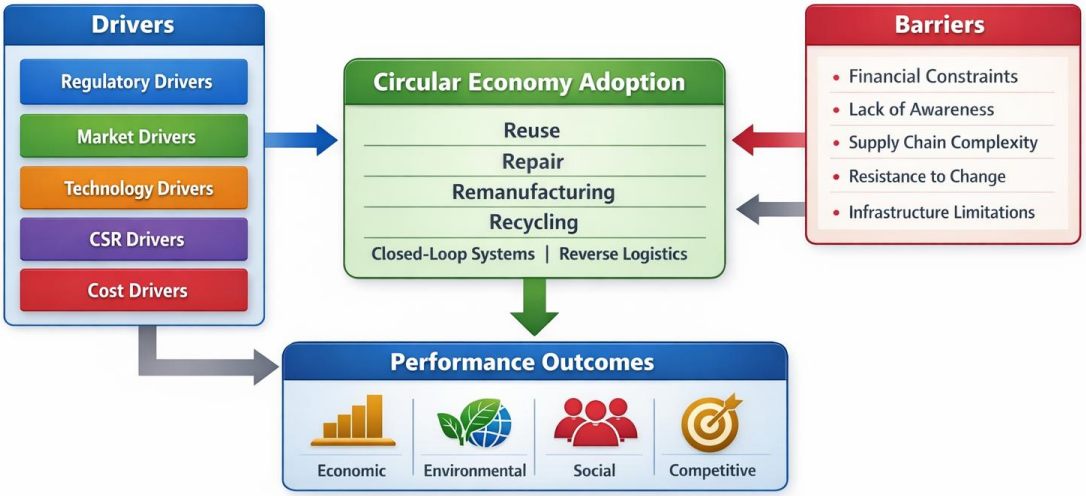
Figure 1: Integrated Conceptual Framework for Circular Economy Adoption in Supply Chains



The circular economy model, as a conceptual model, focuses on the critical decoupling of resource consumption and economic growth while ensuring positive economic, social, and environmental benefits (Scheel et al., 2020; Uddin et al., 2023). The circular economy model focuses comprehensively on the resource-efficiency value chain, ensuring responsible material sourcing, innovative eco-design, sustainable production, product use, and material management. This not only allows the free flow of resources within the blue-cycle economy but also minimizes the need for resource extraction, thereby alleviating the burden on the planet's finite resources while meeting the indispensable resource requirements of the economy. The circular economy model provides a flexible, sustainable framework for industries and sectors, ensuring a long-lasting future.

In order to transition from the existing linear economic model, which follows a take-make-dispose economic paradigm, to a circular economic paradigm, which is an innovative sustainability-oriented economic strategy, all the stakeholders in the entire supply chains must engage collaboratively. The circular society, which focuses on minimizing waste generation, sharing rather than owning, and the repair, refurbishment, and reutilization of assets, and on the management of end-of-life products through strategies such as reuse, remanufacturing, and recycling, inherently creates the necessary demand signals that facilitate the transition. Furthermore, the emergence of new technologies that disintermediate markets and reorganize entire supply chains significantly boosts demand for a wide array of resources (Arun & Ashley, 2007). Simultaneously, the emergence of higher income levels and the employed segment of the population also creates spending patterns that favor resource efficiency, environmentalism, and sustainability. Thus, this new economic model creates a demand for a variety of circular products and fosters a more resilient economic future.

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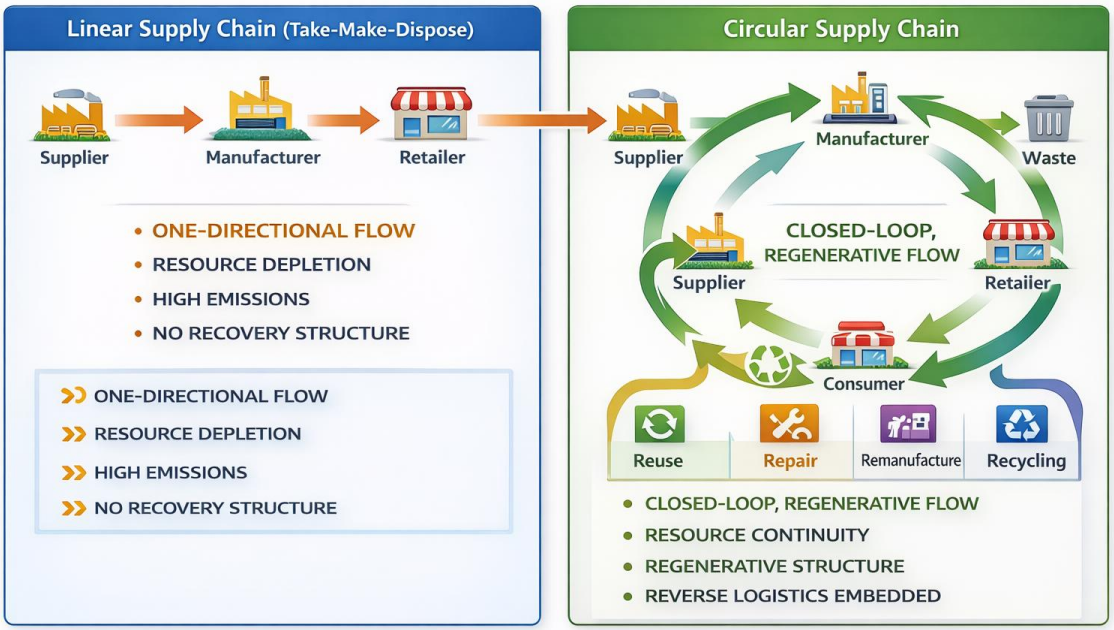
Figure 2: Linear vs. Circular Supply Chain Architecture



III. Importance Of Circular Economy In Supply Chains

Adopting the circular economy in the supply chain has significant implications for profitability, sustainability, and business viability (Kazancoglu et al., 2023). It can be stated that the circular economy concept has the potential to provide a viable solution to sustainable supply chains by focusing on reducing consumption of virgin natural resources. At the same time, the circular economy concept also aims to boost material recycling to close the loops of the production process. In this regard, the benefits of the circular economy concept for individual businesses can be described as multifold. In other words, the circular economy concept can provide benefits to individual business organizations in terms of reduction of greenhouse gas emissions, reduction of material costs to a significant extent, reduction of costs associated with the regulation of waste disposal, improvement of business reputation, and improvement of the potential to be competitive in the market in the long term. Strategic interventions, such as public and private procurement strategies, would be beneficial for facilitating the adoption of the circular economy concept.

It is noteworthy that an increasing number of manufacturers have recognized the need to adopt the circular economy framework to develop sustainable supply chains by addressing the challenges associated with its implementation.

IV. Drivers Of Circular Economy Adoption

The rising concerns about resource depletion, the environmental implications of conducting business in a linear economic model, and the on-going climate change challenge all combine to make the circular economy a necessary and unavoidable opportunity. The role that the principles of the circular economy play in building a more resilient supply chain cannot be overstated, as they mitigate risks associated with disruptions caused by the unavailability of raw materials. As a result, the circular economy is a highly effective strategic model for building resilient, sustainable supply chains in a business environment where environmental concerns are paramount (De Angelis et al., 2018).

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4.1. Regulatory Drivers

The use of regulatory drivers creates incentives for companies to engage in sustainable activities. As a result, a high level of government support is necessary for the development of the circular economy. There is a body of research showing that regulatory drivers play a significant role in the development and growth of the circular economy as a means of building a more sustainable economic model (Aloini et al., 2025). The circular economy action plan developed by the European Commission provides the necessary motivation for companies to develop effective business models directly applicable to the circular economy. The use of policy drivers in the United Kingdom that incentivize businesses in supply chains applying circular economic principles facilitates the transition to the circular economy.Groups of companies across all regions therefore possess sufficient capacity to comply with international regulations that require a circular economic approach in their supply chains.

Additional evidence indicates that policies pursued by national agencies in China are establishing a supportive environment for the development of circular economic activities. As a result, research conducted at the Institute of Geographical Sciences and Natural Resources Research in Beijing has developed a circular economy indicator system to evaluate the status of circular economic initiatives. This system already serves as an effective mechanism to assist Chinese authorities in implementing a transition to a circular economy. Support from national governments for such developments was identified as one of the most important enablers of the circular economy in the recent survey.

4.2. Market Demand

Market demand motivates supply chain actors to adopt circular economy practices. Firms adopting circular supply chains can respond faster to fluctuations in market demand through product or component reuse and remanufacturing (Rizos et al., 2016). Increasing environmental awareness and legislation in consumer markets encourage manufacturers to adopt circular-economy business models (Kumar et al., 2019). Consumers with green purchasing behaviours influence firms to offer environmentally friendly product or service options, further stimulating the adoption of circular supply chains. The substitution of virgin materials with recycled alternatives enables equipment manufacturers to supply environmental solutions that, while competing with entrenched linear models, stimulate the growth of circular alternatives in markets.

4.3. Technological Innovations

Technological innovations play a vital role in the diffusion of the circular economy concept. The concept presents tremendous opportunities in various industries and sectors. New and advanced technologies in the production sector, such as 3D printing and scanning, are instrumental in developing and advancing innovative circular business models, which are the backbone of sustainability. Furthermore, the ongoing efforts and initiatives of global organizations are a major driving force in promoting resource efficiency and the application of the concept of long-life design, thereby increasing the utilization of inputs and addressing the complexity of modern production processes. New technologies, as discussed in the paper, advancing in artificial intelligence, blockchain, additive technologies, big data analytics, and the Internet of Things, are specifically addressing the major challenges in the circular economy concept. These technologies are successfully enabling smart, autonomous production systems. The successful implementation and application of the circular economy concept across countries worldwide, both developed and developing, demonstrate the role and significance of technology as a major driving force in the supply chain, leading to a sustainable future for the planet.

4.4. Corporate Social Responsibility

Corporate Social Responsibility (CSR) clearly reflects businesses' unwavering dedication to operating ethically and economically while supporting social and environmental sustainability. This involves not only adopting responsible practices but also reporting them to the environment. In addition, CSR is one of the most important factors that encourage the adoption of circular economy (CE) ideology by various supply chains to create a sustainable environment. Through these practices, businesses can create long-lasting impacts on society and the environment, thereby providing innovative opportunities to manage resources sustainably (Maskin, 2018; Nasir et al., 2017).

4.5. Cost Reduction Opportunities

The concept of the circular economy has emerged as one of the most important economic models for sustainable development, addressing problems related to resources, waste, emissions, and energy (Kumar et al., 2019). Cost reduction is considered to be one of the most important factors that can encourage businesses to adopt circular economy practices.

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Organizations can achieve numerous benefits by adopting circular economy practices and strategies, including cost reduction and waste reduction through closed production loops, which is considered one of the most important benefits. Organizations that aim to reduce costs related to energy, resources, water, and emissions can effectively adopt these strategies. Energy cost reduction is considered one of the most important factors for reducing costs while encouraging businesses to adopt circular economy practices and strategies.

V. Barriers To Circular Economy Adoption

Despite growing awareness of the circular economy (CE) as one of the most important economic models that various supply chain players and managers can adopt, numerous barriers remain to its adoption. A lack of awareness regarding CE principles and benefits remains a primary obstacle (Chakraborty et al., 2022). The lack of funding for start-up initiatives essential to supporting CE efforts within supply chains also impedes transformation away from traditional linear models. Complexity within supply chains poses another challenge; unclear interactions among supply chain nodes can deter stakeholders from embracing necessary changes (Rizos et al., 2016). Resistance to modification of established processes further restricts adoption, as does inadequate infrastructure to accommodate the logistical requirements of circular systems (Kumar et al., 2019). These barriers operate alongside well-documented drivers—such as regulatory support, market demand, technological readiness, corporate social responsibility, and cost savings—and must be addressed to facilitate the broader implementation of CE practices.

5.1. Lack of Awareness

Many SMEs have never heard of the circular economy or do not understand its meaning (Rizos et al., 2016). The transition to a circular economy requires a collective effort, encompassing knowledge-sharing and behavioural as well as technological innovation among different stakeholders. Companies that guard information for perceived competitive advantage or struggle to communicate their expertise often hinder the development of circular business models. Lack of technical and technological know-how is an important barrier, particularly for SMEs intent on transforming their linear business model into a circular one. The transformation of operational processes requires new, sustainable technologies, which in turn demand professionals with specific skills—a supply–demand gap that compromises the capacity-building process.

Insufficient investment in eco-design and resource-efficiency technologies (both perceived as costly), together with the low pricing of raw materials, also impedes the uptake of a new production paradigm. Adopting circular business models usually implies collaboration across the supply chain. Yet some supply-chain partners hesitate to participate for three main reasons: reluctance to share private information; the perception of a competitive disadvantage; and overall disinterest in circularity, especially when staff and key stakeholders resist change. Finally, circularity increases the complexity of supply chains, and affects the logistics-regulation-financial nexus needed to support new operating practices.

5.2. Financial Constraints

Finance is a critical factor for small and medium-sized enterprises (SMEs) in their progress towards a circular economy (CE). Many SMEs face difficulties in securing financial support from banks, venture capitalists, or business angels (Chakraborty et al., 2022). Financing problems are indeed prominent barriers hindering CE adoption (Rizos et al., 2016). Investments in eco-design, resource efficiency, and circular technologies are not yet mainstream, and SMEs often lack the necessary funds to develop or implement these initiatives. Moreover, low raw material prices reduce the motivation to pursue circular economy approaches, as the economic benefits may be uncertain or limited in the short term.

5.3. Supply Chain Complexity

Supply chain complexity can hinder circular economy adoption by limiting visibility and complicating the design of closed-loop supply chains (De Angelis et al., 2018). Excessive product variety also exacerbates this difficulty. Successfully organizing recovery and remanufacturing activities into the existing supply chain network thus becomes a major implementation challenge. Close collaboration with internal and external parties is critical, requiring co-operative relationships among manufacturers, suppliers, distributors, and retailers. Product recovery for reuse and remanufacture relies on the effective management of the entire reverse supply chain for product collection and inspection. A provision system that directly connects various recovery activities is essential, reflecting the common abnormalities of returned products. Overall, supply chain complexity negatively affects circular economy adoption because organisations may lack sufficient control over the supply chain and the knowledge to effectively address the nonlinearity and dynamics inherent to circular supply chains.

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5.4. Resistance to Change

Resistance to change is a significant barrier to implementing the circular economy. Despite the potential benefits of circularity, firms can find it extremely difficult to abandon the linear model in favour of a circular approach (Kumar et al., 2019). Large, consolidated manufacturing plants are typically the most resistant, due to the formidable challenges of changing well-established, capital-intensive processes. Small and medium-sized enterprises often find the practice easier to adopt due to their flexibility and less complex operations.

In many cases, industry leaders offer incentives to encourage isolated firms to shift towards greater circularity, signalling a move beyond the linear 'take-make-dispose' paradigm. Firms located at the end of production chains may give rise to closed-loop systems, thereby proving the circular approach to be viable and demonstrating its capability to satisfy market demand. Strong consumer pressure can further motivate companies to embrace circular practices; where such pressure exists, more resilient demand for circular products also helps overcome resistance.

The difficulties associated with shifting from linear systems towards more circular ones can be viewed as project risk; the outcome of such change is uncertain and not always positive. Extensive stakeholder involvement throughout the process is therefore essential, together with successful pilot projects that illustrate the benefits of circular operation.

5.5. Insufficient Infrastructure

With the introduction of the circular economy (CE) strategy, organizations are required to transition their supply chain operations to circular models. Infrastructure has been identified as a main challenge for circular economy initiatives (Karlovsek et al., 2024). Studies have identified limited knowledge and underdeveloped infrastructure as barriers to CE adoption. There is limited availability of effective CE infrastructure which makes adoption challenging and prevents CE from functioning properly. Moreover, limited supply chain infrastructure capacity for waste collection, reprocessing, and redistribution, all of which are vital in supporting material recirculation processes in a CE.

The current linear supply chain infrastructure is incompatible with circular operations and support, thereby preventing CE adoption. Additionally, CE infrastructure development requires significant investment and a substantial commitment of time and resources. Nevertheless, infrastructure is considered a necessary pre-condition which enables CE implementation within supply chains (Rizos et al., 2016).

VI. Performance Outcomes Of Circular Economy Practices

Circular economy practices offer the promise of significant economic, environmental, and social performance gains as companies incorporate remanufacturing, recycling, reuse, and repair into the design, manufacturing, and distribution of products and materials (De Angelis et al., 2018). Supply chain management and logistics activities play a pivotal role in the transition from linear to circular economic models in which companies incorporate circular flows into global supply chains. Circular economy practices offer significant opportunities to reduce costs and enhance profitability for companies that pursue them (Nasir et al., 2017), while increasing reuse rates and improving environmental outcomes.

The implementation of circular supply chains, including remanufacturing, recycling, reuse, and repair of products and materials, improves economic, environmental, and social performance. Adoption of circular economy practices can therefore enhance economic, environmental, and social supply-chain sustainability while promoting a more competitive posture; however, the transition to a circular economic model challenges companies to rethink how forward and reverse flows link across multiple tiers and multi-industry lifecycles. Companies operating linear supply chains to design, manufacture, and distribute products have conventionally followed a take-make-dispose model, which contrasts with the circular economy framework, in which resource inputs, waste, emissions, and energy leakage are minimized by closing material and energy loops.

6.1. Economic Benefits

The economic benefits of **adopting** circular economy (CE) strategies have been identified as the main driver of CE adoption. This comprises various aspects of the economy, including innovation, employment generation, increased turnover volume, cost reduction, and risk mitigation (Rizos et al., 2016). Additionally, there is potential to extend product lifespans, reduce raw material consumption, and lower energy use (Nasir et al., 2017). As a result, adopting CE strategies can help organizations reduce the costs of managing materials and parts throughout their lifecycles. This has been emphasized in the context of manufacturing organizations. In the manufacturing field, the various aspects of the economy, including resource scarcity, technological advancements, regulation, business opportunities, and environmental concerns, have been identified as key drivers of CE adoption (Kumar et al., 2019).

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An analysis of the manufacturing organizations of the United Kingdom and the European Union has identified the increased regulatory pressure, waste management costs, and business opportunities as key drivers of CE adoption. In conclusion, the CE paradigm has the potential to deliver economic benefits across multiple dimensions for organizations that aim to incorporate the circular economy into their business operations.

6.2. Environmental Impact

Circular economy adoption positively impacts environmental performance by enabling firms to reduce their use of virgin materials and adopt more sustainable production processes. Support for environmental-driven pressure on adoption would be consistent with findings that firms in cleaner industries are more likely to engage in circular practices (Nasir et al., 2017). A circular economy approach offers value for organizations by treating waste as a by-product rather than discarding surplus materials. Environmental regulations are currently forcing firms to reduce waste and greenhouse gas emissions, as well as to consider take-back and extended producer responsibility schemes.

There are broader external pressures to embed environmental concerns into business operations, such as the UN Sustainable Development Goals and regulatory practices introduced by the European Commission and the United States Environmental Protection Agency (EPA). The EPA is developing proposals to streamline regulations to facilitate regulatory relief for circular economy initiatives. The role of government in driving environmental initiatives is significant and further encourages the adoption of the circular economy. There is growing interest in extended producer responsibility among citizens, customers, and supply chain actors who are increasingly raising their environmental awareness.

In some industries, circular economy practices are required to comply with regulations. Resource scarcity remains acute, which incentivizes firms to implement circular practices and adopt strategies that reduce resource consumption. The EU has already incorporated circular-economy action into its policies, confirming its status as a major priority.

6.3. Social Implications

The paradigm shift towards circular economy challenges organizations to adopt new production models to remain competitive. Adopting the circular economy requires a thorough understanding of the barriers and enablers that affect its implementation (De Angelis et al., 2018).

The construction sector, in particular, has widely incorporated circular economy principles to meet regulatory and customer requirements (Nasir et al., 2017). Due to these factors, there is an increasing demand for tools to help companies evaluate their operational modes and identify necessary changes to achieve circularity.

An empirical investigation identifies the adoption drivers, role of stakeholders, and performance outcomes resulting from circular economy practices. Data collected from companies with circular economy experience reveal an approach to accelerate a company's transition to sustainable operations. Statistical analysis confirms specific industry factors that introduce significant uncertainty in the decision-making process. This approach has been developed into a tailored tool to help understand these influences.

Circular economy models aim to find innovative solutions by adopting regenerative and restorative industrial processes. The core idea is to create an industrial system capable of recovering value from a product at the end of its life. Operational practices include remanufacturing, repair, upgrade, refurbishment, and parts harvesting. The effectiveness of such systems heavily depends on the supply chain structure and requirements. Globally, Bosch pioneered the introduction of remanufactured components in automotive industrial systems, highlighting the practical application of these concepts.

From a social viewpoint, lean production emerged as one of the most important supply chain strategies and has become widespread. Extensive surveying indicates that adopting lean practices inevitably influences social matters. Using a global sample, the relationships between lean practices and social consequences are examined, showing that lean significantly affects employment, organizational culture, and social equity. Specifically, value stream design, pull systems, continuous flow, total productive maintenance, and supplier management are examples of circular economy practices with significant social implications.

6.4. Competitive Advantage

Generally, the adoption of circular economy practices in the supply chain is driven by the need to achieve a competitive advantage, a direct benefit, and to improve accessibility. A few researchers also argue that competitive advantage is one of the outcomes of implementing circular economy principles. Implementing circular economy practices in the supply chain involves changes to the firm's operations and structure at multiple levels, including product design, end-of-life management, and more.

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Implementing circular economy practices in the supply chain is likely to provide a significant level of competitive advantage to the firm, given that it differentiates the firm, improves customer loyalty, and is aligned to changes in customer behavior, in addition to changes in resource configuration to accommodate new regulations and improve access to scarce resources. Circular practices have the potential to drive increased service and product innovation, leading to first-mover advantages and enhanced flexibility and adaptability.

While circular operations contribute to competitiveness, they can also raise capital and operational costs, introducing a trade-off between circularity and cost efficiency. Nevertheless, leadership, management, and strategy are recognized as enabling factors for adopting circular economies, and the adoption of specific circular economy practices positively influences business performance. Hence, circular economy practices have the potential to strengthen competitive advantage (De Angelis et al., 2018).

VII. Case Studies Of Successful Circular Economy Implementation

The adoption of circular economy practices dates back to the early 2000s, as research diversified beyond closed-loop recycling and product recovery strategies. Case studies illustrate the councils, governance changemakers, and industries leading adoption across America, Asia, and Africa (Rizos et al., 2016).

Since 1997, councils and governments in the US, UK, and Australia have encouraged national circular economy initiatives. The European Union has promoted closed material loops in supply chains and envisaged a fully implemented economy by 2035. These institutions operate circular economy-supporting environmental programs and voluntary campaigns. Industry has pursued the reduction and substitution of raw materials and hazardous substances in products, allowing further reuse. Business models have been adopted to start recovering electric and electric components from end-of-life products. In the US, reports covering the reuse and recycling of specific materials quantify economic benefits from decreased landfill use. Numerous other case studies describe various regulatory and theoretical frameworks that implement circular economy principles and outline the necessary transition pathways.

The reported case studies—the earliest dating back to 1970—provide a comprehensive, multinational overview of the implementation dynamics, pathways, and governance of the circular economy.

They illustrate leading regions and countries, changemakers, governance mechanisms, industries, business models, and material groups implementing circular economy frameworks and policies.

7.1. Case Study 1: Americas

Firstly, regulatory pressure is a key driver of CE adoption. The Brazilian Policy of Solid Waste, for example, introduces elements of CE, even though it does not formally use the term, encouraging businesses and waste pickers to engage in integrated waste management (Guarnieri et al., 2020). In addition, the Sectoral Agreement for Reverse Logistics of Packaging promotes a circular economy by clearly defining roles in waste returns. Second, competition-incentive effects encourage firms to consider the circular economy. As the global value chain grows, environmental concerns are a key factor in ensuring profitability and success, prompting firms to consider the circular economy (Kumar et al., 2019). Thirdly, current levels of technology development and maturity enable businesses to explore CE opportunities and benefits. Companies leverage advances in technology to design more sustainable products and processes that align with circular principles. Fourthly, market opportunities arise from government incentives promoting innovative urban systems for CE transition as part of a broader green economy framework (Cristina Silva et al., 2019). Public policies stimulate investment in circular solutions that optimize regional resources. Lastly, pressure from customers' corporate social responsibility drives organizations to foster sustainable environmental practices. A growing consumer preference for green products and services reinforces commitment to circular business models.

7.2. Asia

The transition towards a circular economy has been recognized as a critical shift away from traditional economic models. Asia's rapid industrialization has made it a key target for growth and environmental protection initiatives focused on circular-economy adoption. Currently, China produces more goods than the United States and the European Union combined. Improving the circular economy and mitigating supply chain emissions in Asia could therefore significantly reduce greenhouse gas emissions (Rizos et al., 2016). One example is the Circular Economy Development Strategy and Action Plan of China, which aims to establish a closed-loop, material-recycling system that cuts resource use by 15% during the 13th Five-Year Plan (2016-2020).

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The Chinese government has also implemented incentive policies to encourage investment in the circular economy. At the same time, many large Asian supply chains view circular economy approaches as essential to their sustainability and resilience targets, offering considerable latitude for adoption.

To facilitate large-scale adoption of the circular economy, government policy remains vital. Chinese cities such as Dalian, Changchun, and Ningbo have emitted 41.3%, 35.7%, and 38.3% fewer tonnes of carbon dioxide per million US dollars of gross domestic product (GDP) than the national average. A strategic shift from linear to circular economic models remains necessary, especially among medium and small enterprises, which constitute over 90% of the Chinese economy. In this respect, many local governments in the region have set requirements for the circular economy, such as establishing resource-use assessments and requiring waste reuse as a standard procurement practice. For these purposes, local governments can offer helpline assistance and technical expertise in different areas such as long-term industrial strategy and plant design.

Government attention and investment in the circular economy have been increasing rapidly in Asia. If a government fully supports circular economy initiatives, adoption within supply chains will likely accelerate, due to improved awareness and better investment accessibility. Beyond financial support, governments in Asia have considerable scope to implement policies that encourage circular-economy adoption and practices; these opportunities warrant closer academic and professional examination.

7.3. Africa

The African region maintains a unique stance in its acceptance of circular economy principles despite infrastructural limitations. Formal studies in this context remain limited (Fourie, 2019) , yet sustained economic growth continues to elevate the adoption of circular framework principles within African supply chains. The continued increase in economic growth supports the supposition of rising commitment to adopting circular economy practices by multinational corporations, underscoring the need for enhanced regulations and policies to promote sustainable development on the continent.

VIII. Comparative Analysis Of Circular Versus Linear Supply Chains

Circular economy practices can be viewed as a hybrid form of production organization for managing resource flows, combining aspects of batch processing with continuous flows (De Angelis et al., 2018). Through the deliberate and strategic deconstruction of the conventional linear production organization, circular supply chains aim to create a cyclical pattern of flows in information, resources, goods, and financial flows. The shift away from the conventional unidirectional, one-to-one resource flow pattern, typified by the linear progression of raw materials from the supplier to the manufacturer to the retailer to the consumer, to a complex array of return loops of different forms can be considered a revolutionary concept. Nasir et al. (2017) distinguish the structural composition of linear and circular supply chains, particularly in relation to the dynamic characteristics of the latter. For example, the authors used the construction industry as a case study to show how resources, such as those generated at demolition sites, can be recovered, remanufactured, and recirculated within a flexible, self-regenerating supply chain. This structure may consist of a number of loosely connected entities, each of which is functioning in different directions in a complex manner. In such a state, the structure of the material supply network is dynamic, meaning it changes as the localization of key activities in core recovery and supply shifts in response to demand, regulatory changes, and new opportunities. Regenerative supply chain structures emerge as a concept to address their ability to maintain continuity, at least in part, by replenishing the resources on which they depend.

IX. Role Of Stakeholders In Circular Economy Adoption

Government support for the adoption of circular economy (CE) initiatives is an interrelated factor that has emerged in many studies (Kayıkçı et al., 2022). Regulations and policies are fundamental factors that shape organizations' strategies, leading them to adopt CE. Their role is indirect but significant, as regulations drive the creation of new technologies that improve the CE value proposition (Kumar et al., 2019). Regulations also drive sustainable behavior by dissuading organizations from using non-renewable resources and penalizing them for waste generation, which negatively affects the environment.

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Compliance with green standards improves the company's reputation and encourages customer loyalty. Heavy fines and the risk of shutting down operations push firms towards adoption and allocation of financial resources (Rizos et al., 2016). Consequently, regulations are an essential driver of shifting current production and consumption patterns towards CE principles and of promoting sociotechnical transitions across sectors.

9.1. Government

Government centres are embracing the circular economy as an approach to boost the economy, protect the environment, and enhance citizens' quality of life. Public procurement is a critical tool for supplying the market with affordable secondary raw materials and enabling demand consolidation in the Circular Economy (De Angelis et al., 2018). Various green public procurement policies have been implemented worldwide, including programmes in the European Union, the United States, China, and Japan (Rizos et al., 2016). There is an increasing number of policies addressing Circular Economy at local, regional, and national levels. Signatories of the Multi-City Declaration on the "Circular Economy" are driving circular efforts for a population of 30 million. Countries are increasingly integrating the Circular Economy into their national plans, adopting national strategies to tackle challenges and supporting Circular Economy initiatives and business clusters.

9.2. Industry Leaders

Only a handful of industry leaders, mostly from the manufacturing and recycling sectors, have implemented circular economy principles across their supply chains. Extensive empirical evidence illustrates how organizations implement circular economy initiatives and leverage technologies to capture the associated benefits (Kumar et al., 2019). For example, Dr Lydia Tong Shee has led numerous organizations, including the Centre for Logistics and Supply Chain Management at City University of Hong Kong, in adopting circular supply chain operations (Chakraborty et al., 2022). A comprehensive comparison between linear and circular supply chains highlights the advantages of circular operations for today's manufacturers (Nasir et al., 2017). Stakeholder groups such as governments, executives, and consumers need to be closely considered because of their significant roles in building circular economy systems and optimizing supply chain activities.

9.3. Consumers

A comprehensive understanding of consumers' views, along with the impediments to embracing sustainable and circular economy practices, is considered an essential factor in advancing social sustainability (Rizos et al., 2016). Since consumers are a significant segment of society, their views and impediments to embracing sustainable and circular economy practices are of great importance in advancing these concepts. Moreover, such an in-depth understanding of consumers' views, along with the impediments to adopting sustainable and circular economy practices, is likely to provide governments and organizations with insights to develop effective strategies to encourage consumers to adopt sustainable alternatives. These issues are highly relevant to organizations that have committed to Corporate Social Responsibility (CSR), as failure to address them in a timely manner is likely to result in external environmental and societal implications that negatively affect their values and objectives.

X. Future Trends In Circular Economy

CE prioritizes resource optimization and delivers financial and environmental benefits, but challenges include insufficient management commitment, limited resources, and potential supply chain complexity (Kumar et al., 2019). CE constitutes a strategic framework of innovative and prevailing approaches aimed at replacing the linear take-make-use-never economic model without compromising future generations' needs (De Angelis et al., 2018). Against this background, this section elaborates on future CE trends in supply chains.

The development of new technologies empowers the future growth of circular supply chains (CSCs). Advancements in big data, the internet of things (IoT), and artificial intelligence (AI) enable firms to monitor their resources and manage reverse flows from both a facility-to-customer and a customer-to-customer perspective. The adoption of emerging technologies has a positive effect on new business models aiming to increase circularity. The introduction of Industry 4.0 intensifies the transition towards the recovery of products post-consumption.

For example, the rise of the shared economy and the popularity of remanufacturing are driven by greater transparency, immediacy, digitization, and the ability to manage critical data. Increasing regulatory pressures and government initiatives are driving firms to embrace CE in their operations.

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Technological progress enables organizations to better track resources, further stimulating CE adoption. Because of the increased resilience of CSCs, adopting CE practices improves the performance of UK freight transport. Thoughtful government involvement can incentivize CE adoption across organizations. Access to funding and capital helps adopting CE to develop innovative approaches, improve facility characteristics, and sustain the transition process.

Regions such as Latin America, Africa, and the Middle East are expected to play a pivotal role on the global CE stage. The adoption of circular supply chain (CSC) practices would enable significant CO2 emission reductions from 8 billion tons in 2020 to fewer than 4 billion by 2050. CE strategies positively affect economic, social, and environmental performance; therefore, firms pursuing CE practices within their supply chains can achieve a sustainable advantage by improving operational performance. Continued empirical research is encouraged to deepen the understanding of supply-chain innovation's role in the transition towards CE.

XI. Policy Recommendations For Enhancing Circular Economy Adoption

Circular economy transition hinges on policy effectiveness. Businesses, pioneers of circular models, require a policy mix that eliminates barriers, nurtures innovation, and aligns policy domains (Rizos et al., 2018Coherent policy frameworks provide the basis for transition, with mandates and incentives such as extended producer responsibility, waste management regulations, etc., serving to impose circularity. Lack of mandates, along with insufficient external assistance, creates continuity issues due to misaligned supply chains. Sustainable product design is promoted through public procurement, while the use of substitute resources is in line with market demand and resource scarcity. Lack of financing is a significant challenge, while working with industry leaders, governments, and consumers is a key driver. In the supply chain, complexity, fragmentation, and change resistance create challenges for operational efficiency.

Small and medium-sized enterprises face significant challenges, including financial, behavioral, and managerial challenges. Lack of knowledge, along with regulatory and contractual issues and low top management support, is a challenge to being eco-design ready, according to Rizos et al. (2016). Knowledge and awareness are key to fostering environmental awareness, leading to ecological behavior and the adoption of green practices.

Resistance to change occurs at the individual and organizational levels, and the lack of infrastructure is also a challenge for promoting the adoption of circular economy practices; although top management can impose directives, infrastructure is indispensable. Governmental agencies, industry associations, and industry leaders play a vital role in promoting standards, norms, and communication networks, thereby fostering the necessary synergies.

XII. Measurement And Evaluation Of Circular Economy Performance

In this regard, various indicators and tools for the evaluation of performance in alignment with the principles of the CE have become crucial in the industry's shift to the implementation of the CE business model. The literature has provided a range of approaches for implementing CE in the production system, including frameworks and conceptual models, as well as indicators and evaluation tools. The subject, however, remains a topic of debate due to the lack of empirical application and consensus on the specific indicators for implementing the CE. The various frameworks and models developed by authors on the subject are based on specific dimensions of the CE, for instance, material flow, and focus on the economic aspect rather than the five theoretical principles. The need for the development of a standardized evaluation methodology that is useful and supported by specific indicators, whether qualitative or quantitative, is a subject that requires further research and maturity in the evaluation methodologies for the implementation of the CE. The various factors discussed in the paper on the drivers and barriers to implementing CE in the industry illustrate the interrelation among environmental, social, and economic factors. The overall impact on performance and competitiveness in supply chain management further emphasizes the significance of measurement and evaluation in implementing the CE. Therefore, the use of performance indicators is crucial to implementing the CE principles.

XIII. Challenges In Measuring Circular Economy Success

Adopting the circular economy involves multidimensional considerations, including organizational, operational, and environmental factors. Corresponding metrics constitute these dimensions and are important for evaluating circular economy performance (Cayzer et al., 2017; Howard et al., 2015).

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Although the concept of the circular economy is not new, published reports and journal papers on circular economy drivers and barriers increased considerably after 2015. Empirical studies have mainly focused on surveys or case studies of European companies. Owing to differences in cultural, economic, and policy environments across other regions, it is necessary to examine the factors that promote and impede circular economy adoption outside Europe to gain a more global perspective. Furthermore, as firms try to cope with the complex world, identifying ways to enhance circular economy performance by understanding adoption levels relative to various drivers and obstacles in supply chains becomes especially important.

The circular economy reconstructs the material and energy flows of the supply chain to enable the continuous circulation of these resources and reduce pollution in the ecosystem. Such an operation requires the availability and efficient allocation of corresponding resources (Garcés-Ayerbe et al., 2019). The relative importance of individual drivers also varies across regions, owing to different geographic, demographic, industrial, cultural, economic, and policy environments.

XIV. Conclusion

The study here demonstrates that adopting and integrating the circular economy concept into supply chains offers a green, environmentally friendly approach and a strategic advantage with multidimensional benefits. Although the regulatory environment, technology, market, and financial benefits offer robust drivers for the adoption and incorporation of the circular economy approach, various barriers, such as financial, infrastructural, and supply chain complexities, remain major challenges for its successful implementation. However, the study shows that organizations adopting a circular economy approach have achieved economic, environmental, and social benefits.

However, for the successful implementation and adoption of the circular economy approach, the involvement and engagement of various stakeholders, and the establishment of performance measurement systems to assess the benefits and value created through its adoption and incorporation, remain critical. The regulatory environment plays a critical role in the successful implementation and adoption of the circular economy approach. The circular economy approach represents a paradigm shift in supply chain thinking and practice, as supply chains will now focus on creating value through continuity rather than extracting and exploiting value in linear supply chains.

This article reviews drivers, barriers, and performance outcomes of circular economy adoption in supply chains. The circular economy is a regenerative system that replaces the end-of-life concept with activities of reuse, repair, remanufacturing, and recycling to preserve value and extend the life cycles of products, components, and materials. Leading means of integrating circular economy thinking are through supply chains and by collaborating with customers and suppliers on logistics and remanufacturing. Drivers of adoption include regulatory and legislative pressures, market and customer pressures, technological changes, competitive pressures, cost savings, top management support, and corporate sustainability. Barriers include a lack of knowledge and awareness of the circular economy, insufficient capital for investment, insufficient infrastructure, internal resistance to change, increased complexity, and a shortage of skilled personnel. Circular business models that emphasize collaboration, circular innovation, recycling, reuse, remanufacturing, and remanaging sustainability performance remain better positioned while improving financial, environmental, social, and competitive performance (Kumar et al., 2019; Nasir et al., 2017; Rizos et al., 2016).

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