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Posted Date: 29 November 2024

doi: 10.20944/preprints202411.2338.v1

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Article

Leverage Digital Platforms for Circular Economy: Value Creation View

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Abstract: The practical role of digital platforms in fostering circular economy (CE) among businesses remains unresolved.Unlike previous research on digital platforms and firm performance, this study analyzes the bridging function of the value creation system from a value creation perspective. It identifies resources (business model innovation) and relationships with other value creators (closed-loop supply chain) as key elements for achieve CE.Using survey data from 243 firms, this study validates the significant mediation of business model innovation and closed-loop supply chain in the relationship of digital platforms - CE. This narrows the theoretical gap and expands value creation-based CE research.

Keywords: circular economy; digital platforms; value creation; business model innovation; closed-loop supply chain

1. introduction

The Circular Economy (CE) is viewed as a systematic solution framework designed to address global challenges related to resource use and the environment (Geng et al., 2019). This concept has attracted considerable attention from policymakers, business practitioners, and researchers (Farooque et al., 2022; Genovese et al., 2023). The goal of CE is to create a zero-waste product process by transitioning from a linear model of material-energy flow to a closed-loop system that is recoverable and renewable (Patwa et al., 2021; Triguero et al., 2022). Currently, CE has been extensively studied and implemented at macro-level eco-regions and meso-level eco-industrial parks (Farooque et al., 2022; Liu et al., 2023), with some management and research experience also reported at the micro-level of corporate practices.

For example, Braz and Marotti De Mello (2022) analyzed the critical components of managing supply networks in a circular economy within the complex adaptive systems of enterprises through multiple case studies. Their focus was on how companies organize and manage supply chain members, emphasizing the coordination mechanisms among network partners. Additionally, Figge et al. (2021) employed multi-level selection theory and mathematical models to demonstrate that enhancing overall ecological efficiency in a circular economy leads to improved corporate ecological efficiency. This enhancement is predicated on the sharing of activities, processes, and collaboration. They emphasized that while digital technology plays a significant role in this process, it is insufficient (Cenamor et al., 2019; Figge and Thorpe, 2023; Figge et al., 2021).

Platform technology, or digital platforms, is closely linked to the circular economy and is widely utilized. Digital platforms are technologies that allow businesses to standardize, modify, and distribute data at scale (de Reuver et al., 2018; Jovanovic et al., 2022). They facilitate closer connections, effective communication, and more efficient automation among enterprises, consumers, and suppliers, thus expanding the boundaries of business operations (Broekhuizen et al., 2021; Cenamor et al., 2019). Sedera et al. (2016) described digital platforms as an evolutionary form of information technology infrastructure, including social media, mobile computing, and e-commerce platforms. Through digital platforms, direct engagement with external stakeholders allows one party's active participation to enhance the business value for market participants on the other side

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(Cenamor et al., 2019; de Reuver et al., 2018; Jovanovic et al., 2022). Consequently, the emergence of digital platforms expands the boundaries of business activities, challenging the fundamental principles of traditional enterprise value creation (Rohn et al., 2021).

Digital platforms, including blockchain, big data analysis, cloud technology, industrial simulation, and the Internet of Things, are open, affordable, and widely accessible (Broekhuizen et al., 2021). For example, Bumble Bee employs a blockchain-based cloud platform to enhance and modernize the security and traceability of its seafood delivery, while Alibaba leverages digital platform technology to ensure food safety and promote a sustainable supply chain network by monitoring product delivery information from production to final consumption. These efficient information systems exhibit reliability, security, transparency, and intelligent execution, rendering them highly valuable in the practical application of CE (de Reuver et al., 2018; Ha et al., 2023). Furthermore, digital platforms play a critical role in promoting CE by providing substantial support (Rosa et al., 2020).

The internal mechanisms of digital platforms in promoting CE have not been thoroughly explored and remain a significant research question. Most existing literature relies on single-case deduction studies of individual enterprises or cross-case analyses of multiple enterprises (Genovese et al., 2023; Jansen et al., 2022). Although the findings have substantial implications for the advancement of CE, they are not universally applicable. This implies that the strategic adjustments and technological investments that result in high CE performance in some enterprises may not be suitable for all, even within the same industry. Moreover, in practice, it has been observed that while digital platforms enhance information integration, decision-making quality, and resource efficiency, they may also increase the complexity of business processes (Di Maria et al., 2022; Jovanovic et al., 2022). For example, General Electric (GE) encountered operational conflicts during the adoption of digital platforms, resulting in business failures.

Simultaneously, the complexity of the value creation process implies that adopting digital platforms may not directly result in changes to enterprises' practices and behaviors for CE. Deeper transformations are necessary, including enhancing the dynamic capabilities of enterprises and innovating business models (Ahmed et al., 2022; Braz and Marotti De Mello, 2022; Broekhuizen et al., 2021). Research has demonstrated that various digital platforms have transparently altered the methods of enterprises' value creation and competitive advantage (Chandna, 2022). This not only necessitates that enterprises redesign their operational processes but also develop the corresponding resources and capabilities to support new customer value creation (Ancillai et al., 2023). Digital platforms are shifting the focus of enterprise value creation towards networks, necessitating a significant transition to more externally oriented organizations (Ha et al., 2023; Jonkman et al., 2022).

Therefore, in the complex relationship between digital platforms and CE, there likely exists an unknown system capable of generating value for CE. This study aims to explore the internal mechanisms by which digital platforms influence CE from the perspective of value creation.

Exploring the connection between digital platforms and the CE through the lens of value creation is both innovative and aligned with current business practices. Firstly, a corporation's value creation system delineates how enterprises enter markets and generate value, distinguishing them from other organizations (Freudenreich et al., 2020). Secondly, the primary obstacles for enterprises in achieving CE are organizational rather than technical, particularly concerning value creation systems (Lüdeke-Freund et al., 2019). Lastly, the failure of GE demonstrates that merely integrating digital platforms into existing corporate practices is insufficient. The fundamental reason is that the connection between digital platforms and CE requires firms to reconsider their value creation systems within the supply chain context. Value creation encompasses the broader activities of generating and delivering value. Within the supply chain context, value creation systems facilitate an understanding of the contemporary business environment, where firms operate as interconnected networks rather than isolated entities. Consequently, an enterprise's value creation system must not only transform its internal business model but also collaborate in co-creating and transferring value with other companies (Codini et al., 2023).

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Given the current emphasis on the critical role of value creation in the development of the CE, this study identifies and elaborates on the components of a value creation system. We deduce business model innovation and closed-loop supply chains from two aspects of the value creation process. The research findings not only address the relevant studies and reports on integrating business model innovation and closed-loop supply chains (Lüdeke-Freund et al., 2019) but also advance the fields of CE and value creation.

The structure of the remaining study is as follows: Section 2 reviews the current state of research on the research question. By reviewing the literature, the research proposes and constructs the theoretical model. Section 3 develops the research hypotheses. Section 4 presents the sample characteristics used in the analysis and examines the validity of the data and model. Section 5 details the data analysis process and summarizes the verification results. Finally, the theoretical contributions and practical implications of the study are discussed in Section 6.

2. Literature Review

2.1. Circular Economy

Natural resource scarcity is a crucial factor impacting economic efficiency and production continuity. In an overproducing modern economy, meeting the needs and desires of a growing population demands significant natural resources, which are being progressively depleted. Consequently, scholars and practitioners have implemented numerous attempts and initiatives. These measures assist companies in reducing or even eliminating natural resource consumption while closing the material cycle to prevent waste generation (Lüdeke-Freund et al., 2019; Nikolaou et al., 2021; Suhandi and Chen, 2023). It is widely recognized that these practices are central to CE, requiring all economic participants to shift from linear to circular thinking (Geng et al., 2019).

CE is based on a social production-consumption system, aiming to maximize material and energy utilization within the economic framework while controlling throughput. Its principles involve using periodic material flows, renewable energy, and cascading material and energy flows (Nikolaou et al., 2021). Based on research in engineering and natural sciences, Korhonen et al. (2018) proposed the material flow model shown in Figure 1. In product recycling, items are reused, remanufactured, and refurbished, requiring fewer resources and energy and proving more economical than traditional material recovery from waste products. The longer a resource stays within the inner cycle, the greater its value. In the material cycle, once raw materials are extracted and processed into products, it makes economic and commercial sense to utilize the value generated for as long as possible. This entails maintaining the function/service and use value of products in the economic cycle for as long as possible (Suhandi and Chen, 2023). This approach also tends to yield environmental benefits compared to the traditional linear model of extraction, production, use, and disposal in the modern global economy.

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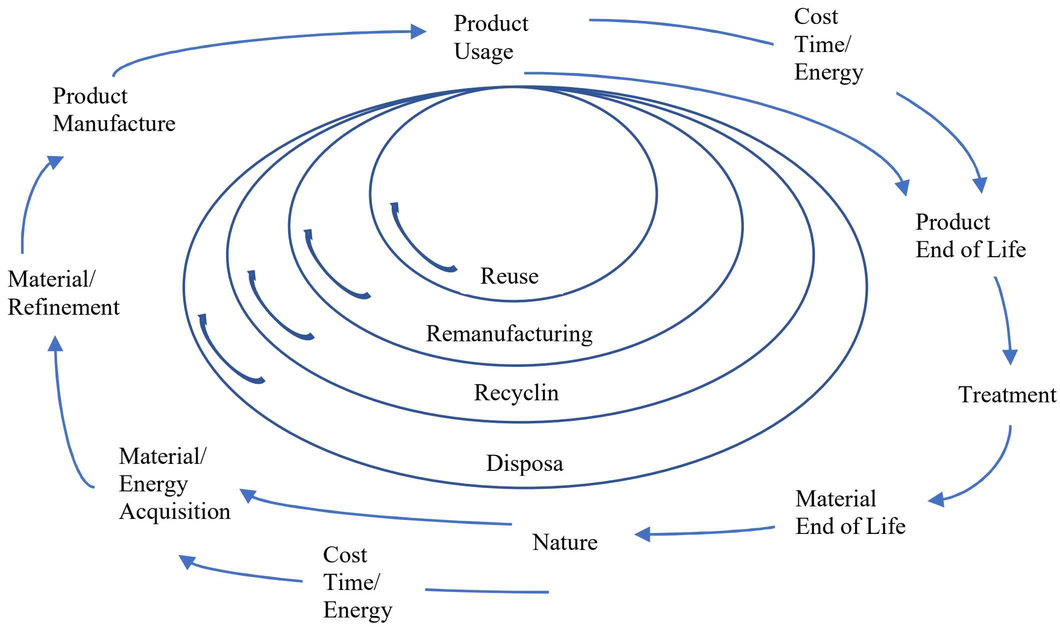

Figure 1. Patterns of material flows in CE.

Therefore, CE primarily focuses on enhancing natural resource conservation and environmental protection. Scholars define it as "a regenerative economic system that minimizes resource input, waste discharge, and energy leakage by slowing, closing, and narrowing material and energy loops." Enterprises can achieve this through sustainable design, maintenance, repair, reuse, remanufacturing, refurbishment, and recycling (Kirchherr et al., 2017).

The CE concept is a compilation of ideas from various emerging fields and semi-scientific concepts (Genovese et al., 2023; Nikolaou et al., 2021). This includes areas such as industrial ecology, clean production, socio-ecological systems, and economic performance (Suhandi and Chen, 2023). The most influential foundational concepts of CE are the "cradle-to-cradle" notion of "ecological benefits" developed by business practitioners and the industrial ecology concept of envisioning industrial ecosystems (Braungart et al., 2007; Geng et al., 2019).

Research on CE can be categorized into three distinct levels: the national and regional level, the industrial management level, and the enterprise supply chain level (Nikolaou et al., 2021). At the national and regional levels, policymakers establish policies and norms aimed at achieving sustainability goals, focusing on integrating CE principles into national strategies (Liu et al., 2023). The EU and China, as early adopters of CE principles in their development strategies, have implemented these policies (Farooque et al., 2022). McDowall et al. (2017) conducted a large-scale analysis of the effectiveness of these policies. They found that both CE policies have achieved notable successes in environmental performance, despite the differing institutional systems of the two regions.

The second level involves cooperation between enterprises to advance sustainable development. At this level, enterprises facilitate the effective exchange of waste materials, achieving a cradle-to-cradle material cycle (Braungart et al., 2007). For instance, principles of industrial ecology and symbiosis are employed to develop eco-industrial parks (Gomes et al., 2023). In eco-industrial parks, the waste from one company can serve as raw materials for another (Figge et al., 2021). To illustrate this, Figure 2 depicts a cradle-to-cradle supply chain model by simplifying complex supply relationships. For example, Firm2's products flow to the downstream market (represented by thick lines), while Firm1's returns from Firm2 may include accounts, waste products, or intangible information and market opportunities (represented by thin lines). Therefore, enterprises in a circular

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supply chain establish strong material and information interactions, necessitating effective communication and coordination (Braz and Marotti De Mello, 2022).

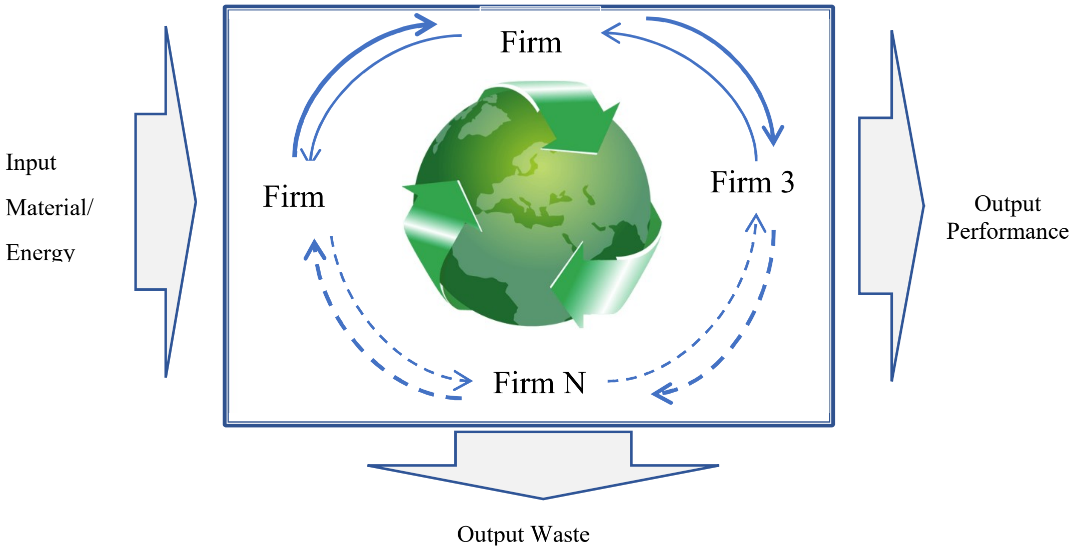

Figure 2. A cradle-to-cradle supply chain model for CE.

The third level of analysis focuses on the firm level. At this level, classical CE principles are integrated into operational and production processes, including reuse, recycling, redesign, remanufacturing, and refurbishment. This level emphasizes the actions taken by individual firms to address sustainability issues. To aid firms in optimizing the reusability of production materials and reducing natural resource consumption, researchers have proposed various methods and practices. These include carbon emissions/carbon footprints, green finance, blockchain/Internet of Things technology, renewable materials, and circular economy business models (Ferasso et al., 2020).

While practitioners and scholars have employed diverse approaches from various fields to study CE, this also highlights significant theoretical and practical inconsistencies and gaps that challenge scholars and policymakers in designing effective CE strategies (Genovese et al., 2023; Nikolaou et al., 2021). Academic journals show substantial interest in CE and sustainable development (Nikolaou et al., 2021), contributing significantly to the development of CE concepts (Kirchherr et al., 2017; Korhonen et al., 2018), evaluation index systems, and performance assessments (Corona et al., 2019; Moraga et al., 2019). However, existing literature weakly integrates technological solutions from engineering and natural sciences with social sciences. The goal is to bridge technological and material life cycles to address the economic, managerial, and social objectives of contemporary society.

This study aims to enhance the linkage between technology and CE within economic management and social sciences and to investigate the impact of digital platforms on CE. The research will integrate concepts from the meso industry layer and the micro-enterprise layer to develop a value creation system that enables enterprises to achieve CE and address gaps in current research.

2.2. Value Creation System in Circular Economy

At the firm level, CE practices involve integrating circular principles into the supply chain to achieve zero waste. Implementing CE requires the efforts of all members within the supply chain (see Figure 2). In modern production and consumption systems, individual companies control only a limited segment of the process and are insufficient to address the systemic requirements of CE practices. Therefore, the entire supply chain activities of enterprises need to be re-examined (Ferasso et al., 2020; Korhonen et al., 2018). The key to adjusting supply chain practices lies with focal enterprises. Research on CE practices in manufacturing enterprises primarily focuses on four areas:

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technology-driven factors, institutional pressure, market demand, and organizational culture (Grafstrom and Aasma, 2021; Nikolaou et al., 2021).

Research on technology-driven CE highlights the information advantages provided by advanced information technology applications, including transparency, sharing, and integration (Grafstrom and Aasma, 2021; Rosa et al., 2020). The significance of technology application is evident in the value-creation process within and across organizational boundaries (Chandna, 2022; Jonkman et al., 2022). The value-creation process involves the activities through which an organization or group creates and delivers value, focusing on the network level rather than on individual organizations (Gomes et al., 2023; Jonsson et al., 2008). Consequently, value can be generated not only within a single company but also through interactions between different companies (Freudenreich et al., 2020).

Two crucial concepts in the value creation process are core competence and relationship roles (Jonsson et al., 2008). Core competencies encompass the essential activities, resources, and capabilities needed in the value-creation process. Conversely, the value creation process involves various participants, their roles, and their interrelationships. Participants may include partners, suppliers, and distributors, who collectively contribute to value creation (Freudenreich et al., 2020). Thus, core competence and relational roles shape how enterprises create value and the value output they generate (Jonsson et al., 2008; Ludeke Freund et al., 2019). This study contends that the value creation system linking digital platforms and CE consists of core enterprises' capabilities or resources for circular and sustainable development—specifically, business model innovation—and well-defined relationships and role positioning with other value creation participants, specifically, the closed-loop supply chain.

Business models operate within a dynamic triangle comprising business strategy, information and communication technology, and business organization (Zott et al., 2011). Different business models offer various benefits, providing companies with flexibility and opportunities to sustain existing advantages and foster innovation (Carayannis et al., 2015). This implies that a company's business model is not static. Instead, companies should adapt their business models in line with technological advancements to ensure sustained market performance and competitive advantage (Ancillai et al., 2023).

Business model innovation refers to the ability to reconfigure existing resources and capabilities. This innovation alters how firms create and capture value for their stakeholders. It is considered both a strategic choice and a continuous strategic orientation for enterprises (Codini et al., 2023). Incorporating social and environmental priorities into organizational development goals leads to the transformation of existing business models. Consequently, enterprises seeking CE benefits naturally innovate their business models to align with CE goals (Freudenreich et al., 2020).

Regarding the relationships and roles within the value creation system, Figure 2 illustrates an essential structure in the operation of CE: the closed-loop supply chain.

A closed-loop supply chain is defined as "a design and operational system that maximizes the creation and recovery of value throughout the entire life cycle of material products" (Brydges, 2021). It involves the relationship and collaboration between various economic and non-economic actors (Zhou and Smulders, 2021). Additionally, it facilitates both the forward and reverse flow of resources and capabilities among related companies and supply chains (Brydges, 2021). This system reflects the flow of energy and material within CE context and highlights the role of participants and the flow of value in the value creation system.

The study found that business model innovation and the closed-loop supply chain jointly constitute the value creation system linking digital platforms with CE (Figure 3). This perspective is supported by the research of Ludeke Freund et al. (2019) and Geissdoerfer (2018), which highlights the crucial role of new business models and closed-loop supply chains in advancing CE theory. Business model innovation is essential for achieving CE, as it transforms how companies create and deliver value. However, achieving CE performance requires more than just changes within a single enterprise; it necessitates the cooperation and participation of all supply chain members (Gomes et

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al., 2023). The closed-loop supply chain defines the roles and relationships involved in transmitting and acquiring value within the value creation system.

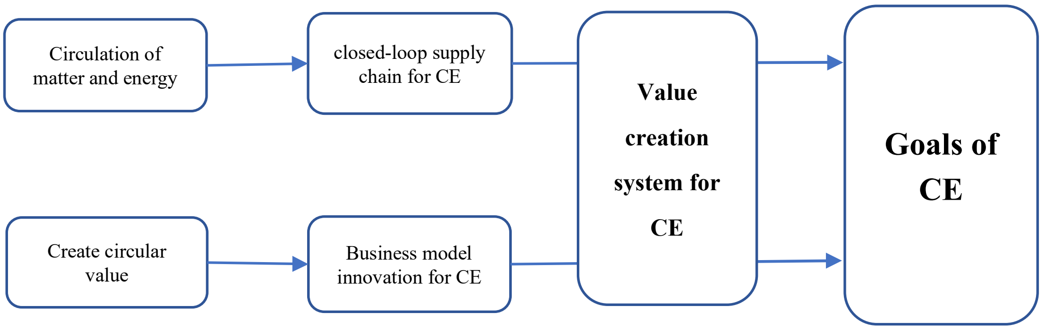

Figure 3. Value creation system for CE.

Currently, there is a lack of empirical data on the relationship between enterprise value creation systems and CE. To address this gap, the study posits that while closed-loop supply chains and business model innovation are distinct factors, together they form the value creation system for CE. The study also demonstrates the positive role of this system in linking digital platforms with CE through quantitative research methods. Based on these insights, we developed the research model presented in Figure 4.

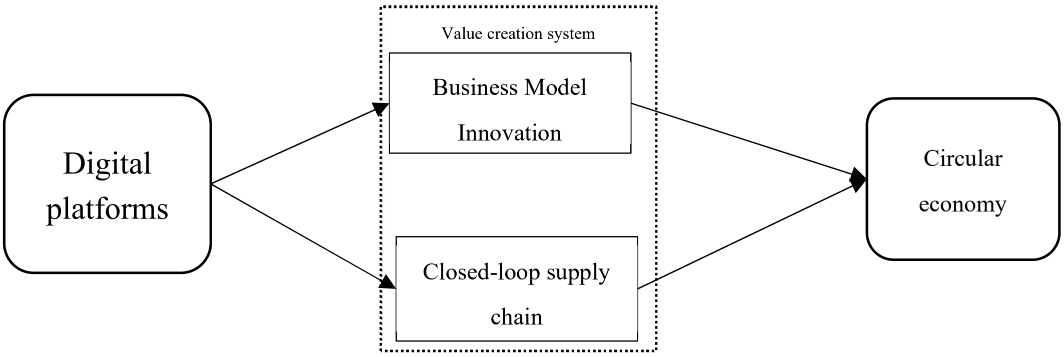

Figure 4. Research model.

3. Hypothetical Development

3.1. Digital Platforms Enable Value Creation System

The analysis of the value creation system reveals that achieving CE results from collaborative interactions among cross-organizational entities and various stakeholders (Gomes et al., 2023). This dynamic aligns with the expanding nature of digital platforms and the evolving boundaries of networked organizations (Chandna, 2022).

Based on the foundation of digital technology, digital platforms manage various types of information and regulate participant behaviors through established norms and organizational processes (de Reuver et al., 2018; Jovanovic et al., 2022). Specifically, digital platforms facilitate access to external knowledge resources from diverse sources (Cenamor et al., 2019). They enable firms to integrate, analyze, and leverage crucial shared knowledge resources for strategic decision-making. Consequently, enterprises reallocate both internal and external resources to address complex and dynamic market challenges (Ahmed et al., 2022; Broekhuizen et al., 2021; Jovanovic et al., 2022). Therefore, digital platforms disrupt traditional business processes, transform industry structures,

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and enhance firms' value-creation capabilities (Cenamor et al., 2019; Sedera et al., 2016). This study will illustrate how digital platforms facilitate value-creation systems within the context of CE.

3.1.1. Digital Platforms and Business Model Innovation

In practicing CE, enterprises pursuing business model innovation must not only focus on internal resources and capabilities but also integrate external market and supply information to foster collaborative progress within the supply chain (Ferasso et al., 2020). Clauss (2017) highlighted that three dimensions of the business model—new value proposition, new value creation, and new value delivery—can drive changes in the business model (Clauss, 2017). Each of these dimensions requires support through new resources or capabilities. Of these resources, the adoption of innovative technologies has the most significant impact on business model changes in the current context (Ancillai et al., 2023). The adoption of new technologies inevitably impacts the allocation of resources and manpower within enterprises, altering their internal structure, production processes, and overall operational modes (Rohn et al., 2021; Xie et al., 2022). Likewise, when a firm adopts new technological approaches, it tends to form new partnerships to facilitate technology integration (Centobelli et al., 2022).

The effective adoption of digital platforms allows enterprises to integrate both internal and external information and resource flows, facilitating the development of efficient vertically and horizontally integrated manufacturing systems (Centobelli et al., 2022; Rohn et al., 2021). System information aids organizations in coordinating both internal and external business processes and reconfiguring associated resources. These capabilities empower enterprises to implement data-driven strategies throughout all stages of the product lifecycle, from raw material procurement to subsequent value-added processes (Ahmed et al., 2022; Rosa et al., 2020).

The use of digital platforms has improved enterprises' ability to absorb external knowledge from virtual environments and integrate it with internal knowledge, making them more knowledge-driven (Cenamor et al., 2019; de Reuver et al., 2018). For instance, car-sharing service providers utilize digital platforms to synchronize user location, demand, performance, and pricing information. An example is Didi Chuxing, a Chinese company. Without a digital platform, users would have to visit rental companies in person rather than select a nearby vehicle. Consequently, car sharing would become less convenient and efficient due to complex procedures. Moreover, inaccuracies in vehicle availability and return locations can lead to losses for both enterprises and customers.

Consequently, digital platforms help enterprises balance knowledge and innovation, boosting business dynamism and proactively seizing opportunities. Enterprises can leverage extensive knowledge to innovate business models and adapt to market demands, facilitating their transition to a circular economy (CE). Based on this, the following hypothesis is proposed:

H1: Higher levels of digital platform application are associated with greater levels of business model innovation.

3.1.2. Digital Platforms and Closed-Loop Supply Chain

The operation of a closed-loop supply chain requires consideration of not only cost and service but also social and environmental factors, thereby complicating its objective function (Govindan et al., 2023). In addition to positive commodity flow, the closed-loop supply chain introduces reverse waste product flow, increasing system uncertainty (Zhou and Smulders, 2021). Particularly in raw material supply, the collection of waste products involves significant uncertainty regarding quantity, quality, and timing. Furthermore, during recycling, the demand of upstream manufacturers or recyclers often does not align with the supply from downstream distributors or customers, leading to a mismatch between new product production and old product recycling (Goltsos et al., 2019; Govindan et al., 2023). This misalignment exacerbates supply and demand uncertainty among supply chain members and increases the overall complexity of the system.

Thus, the closed-loop supply chain must integrate and share both forward and reverse materials and information to facilitate partner cooperation in value creation (De Giovanni, 2022). Firms must

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employ advanced information technologies to enhance supply chain connectivity and foster inter-firm synergy (Oliveira-Dias et al., 2023; Chandna, 2022; De Giovanni, 2022). Digital platforms facilitate end-to-end supply chain connectivity, weaving together and integrating supply chain nodes to create a more adaptable network structure (Ivanov et al., 2022; Rosa et al., 2020). This flexibility accelerates the reallocation of resources between upstream and downstream supply chain segments.

The use of digital platforms enhances the sharing of skills and information among partners. This enhancement optimizes resource allocation in the supply chain and enables diverse collaboration, thereby supporting more effective implementation of closed-loop supply chains (Ahmed et al., 2022; Ivanov et al., 2022). Additionally, digital platforms integrate operational information from supply chain partners. This integration streamlines internal business processes and fragmented subsystems, enhancing overall resource allocation and collaboration throughout the supply chain to better support circular operations (Cenamor et al., 2019; Jansen et al., 2022). This reduces economic and reputational losses from information and trust discrepancies and improves operational efficiency within the closed-loop supply chain, thereby facilitating better achievement of CE (Suchek et al., 2021). Therefore, the study proposes the following hypothesis:

H2: The higher the level of digital platform application is, the better the closed-loop supply chain operation is.

3.2. Value Creation System and Circular Economy

This section specifically addresses the critical role of two elements within the value creation system for CE. The resource-based view underscores the necessity of resources characterized by social complexity, path dependence, or ambiguous causality in sustaining a firm's competitive advantage. These resources are, in turn, bundled with the essential enterprise capabilities required for leveraging them (Barney et al., 2021). In other words, firms that can effectively utilize resource advantages hold a competitive edge over those possessing only the resources without the accompanying capabilities. This study posits that an enterprise equipped with a robust value creation system can fully exploit the benefits of digital platforms to advance CE. Subsequently, we will develop hypotheses focusing on two key aspects: business model innovation and closed-loop supply chain.

Business model innovation represents a key internal component of the value creation system, encompassing an enterprise's ability to perceive information, identify opportunities, and reallocate resources in response to a dynamic market environment (Codini et al., 2023). This capability not only ensures the survival of enterprises but also enables them to adapt to and influence a turbulent business landscape (Clauss, 2017). Conversely, the closed-loop supply chain, as an external element of an enterprise's value creation system, integrates and coordinates various types of material flows—both positive and reverse—alongside related immaterial flows, such as information and financial transactions. It also encompasses the different entities involved in these resource flows, including upstream and downstream enterprises within the supply chain (Govindan et al., 2015; Zhou and Smulders, 2021).

3.2.1. Business Mode Innovation in Value Creation System

The business model articulates the value that a company creates and for whom it creates this value (Zott et al.2011). However, a business model is not static; it must evolve continuously to address changing conditions. To thrive in "turbulent times," companies must develop new business models that include suppliers, partners, distribution channels, and alliances to extend and leverage company resources effectively (Figge et al., 2021). Therefore, to profit from a rapidly changing market, firms need to be adept not only at product innovation but also at business model redesign.

Business model innovation serves as a crucial micro foundation for a corporation's value creation. Enterprises that innovate their business models possess greater potential, resources, and capabilities to develop novel solutions and transform environmental and social challenges into market opportunities (Clauss, 2017; Freudenreich et al., 2020). By adopting business models aligned

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with CE, firms can create new business opportunities, markets, and jobs. This is achieved by maximizing the value of materials through multiple cycles of use, as opposed to the linear "use-once" model prevalent in modern economic systems (Ferasso et al., 2020; Ludeke Freund et al., 2019).

One prominent example is the "sharing economy," which revolutionizes the traditional "production-sales" model by decoupling car ownership from usage rights. This model not only reduces operational and sales costs for automotive companies but also lowers usage costs for consumers. Additionally, it facilitates increased product recycling, such as offering refurbished products, encourages purchases among low-consumption groups, and supports the sustainability of enterprise operations (Freudenreich et al., 2020).

Secondly, the Circular Economy (CE) extends traditional business and environmental management systems by promoting material recycling and energy cascades across sectors, organizations, and life cycles to maximize the economic value of resources (Ferasso et al., 2020; Suchek et al., 2021). Achieving CE requires advanced inter-organizational and network-level environmental and sustainability management systems. Despite progress, many organizations still need to enhance their cross-organizational and network-based approaches to fully realize the CE vision.

Business model innovation plays a crucial role in this process by adopting a multi-stakeholder, multi-system perspective on value creation. Traditionally, firms focused primarily on customers and shareholders. However, with business model innovation, companies now address a broader range of stakeholders and expand their concept of value. Instead of solely pursuing economic benefits, they aim for the triple bottom line: economic, social, and environmental gains (Freudenreich et al., 2020; Ludeke Freund et al., 2019).

Therefore, CE necessitates a redefinition of value creation within the enterprise value chain. This transformation requires changes in the business model to align with corporate strategic goals and enhance cooperation with relevant stakeholders (Suchek et al., 2021). As such, business model innovation is crucial for realizing CE (Carayannis et al., 2015) and serves as a pivotal element in the relationship between digital platforms and CE. Based on this framework, the study proposes the following hypotheses:

H3: Enterprises with higher levels of business model innovation exhibit higher level performance of CE.

H4: Business model innovation mediates the relationship between digital platforms and CE.

3.2.2. Closed-Loop Supply Chain in Value Creation System

Another crucial element of the value creation system is the closed-loop supply chain. The closed-loop supply chain is a designed, controlled, and operated circular system for product manufacturing (De Giovanni, 2022; Goltsos et al., 2019). Its goal is to maximize value throughout a product's life cycle and to dynamically recover value from various types of returns over time (Zhou and Smulders, 2021). It comprises a series of operational links and associated enterprise networks, including procurement, production, recycling, testing, reprocessing, redistribution, and scrap processing (Brydges, 2021). Unlike the traditional supply chain model, a closed-loop supply chain incorporates elements such as product recycling and reprocessing to close material loops, thereby reducing pollution emissions and waste while lowering product costs (Suhandi and Chen, 2023).

The closed-loop supply chain integrates the traditional forward supply chain with the reverse supply chain (Schenkel et al., 2015). Due to increased environmental pressures and producer responsibilities, companies must enhance their management of after-sales and product return issues. Previously, value creation was understood to focus solely on the forward supply chain, neglecting the reverse supply chain as a value-creating mechanism (Schenkel et al., 2015).

The forward and reverse supply chains, along with their interaction, form the foundation of value creation in a closed-loop supply chain. In an integrated closed-loop supply chain, the forward and reverse supply chains work together to achieve the shared goal of maximizing value (Schenkel

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et al., 2015). The forward and reverse supply chains influence each other, as decisions in one chain impact the processes in the other (Govindan et al., 2023; Govindan et al., 2015). In a closed-loop supply chain, materials can be sourced from both new materials and recycled components. This shift may alter supplier relationships, as suppliers might lose new business but gain from refurbishing returned components. Consequently, manufacturing and remanufacturing become at least partially integrated. For instance, product modularity in the forward supply chain facilitates remanufacturing, as old products in a reverse supply chain can be quickly dismantled and returned for remanufacturing.

Efficient closed-loop supply chain management yields direct economic benefits. For instance, utilizing parts and components recovered from used products in the manufacture of new products can significantly reduce resource input and inventory levels. By implementing remanufacturing, core enterprises can reduce raw material purchases and minimize waste and resource depletion associated with new products. The entire supply chain can lower waste disposal costs and address issues related to scarce natural resources and waste management (Brydges, 2021). The closed-loop supply chain offers a comprehensive channel for both forward and reverse material and information flows, facilitating product recycling and remanufacturing (De Giovanni, 2022). Additionally, it provides companies with opportunities for indirect profit. For example, companies can gain insights into market demand and enhance customer satisfaction through data analysis.

The closed-loop supply chain aims to mitigate the negative effects of excessive resource consumption and waste output in business operations through closed resource flows. Recycling and reusing waste products help reduce waste generation and environmental pollution. This approach not only enhances the green image of enterprises but also promotes the harmonious development of the economy and environment (Zhou and Smulders, 2021). Resource recycling also maximizes the value extracted from resources. By processing recycled waste products for reuse or conversion into new raw materials, the service life of resources is extended and the demand for new resources is reduced. Additionally, adopting green processes and practices—such as reducing energy, packaging, water, and non-renewable resource use—enables closed-loop supply chain activities to significantly enhance the environmental performance of both the company and the entire supply chain (Brydges, 2021).

Thus, a closed-loop supply chain aims to maximize value creation and recovery throughout the product lifecycle, aligning with the principles of CE (Schenkel et al., 2015). Based on the previous discussion, it is evident that digital platforms enhance the attributes of a closed-loop supply chain. This enhancement also increases the closed-loop supply chain's contribution to CE. Therefore, the research proposes the following hypotheses:

H5: Enterprises with better implementation of closed-loop supply chains have higher level performance of CE.

H6: The closed-loop supply chain mediates the relationship between digital platforms and CE.

4. Research Methods

4.1. Questionnaire Development

The instrument of this study was specifically designed to investigate the performance of firms utilizing digital platforms in CE development. Hile existing literature offers some guidance on constructing operational measures in this field, it does not fully address the unique context of this study. Therefore, we defined our measurement items by adapting accepted concepts and constructs from previous research to fit our specific context. This approach ensures that the measurement instrument is both theoretically grounded and contextually appropriate. Detailed operationalization of the tool is provided in Appendix A.

To ensure the suitability and effectiveness of the questionnaire, we undertook the following steps. First, we reviewed relevant literature to identify indicators associated with the constructs of interest, prioritizing indicators from quantitative studies where possible. Next, we developed a draft

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questionnaire based on these indicators. This draft was then rigorously evaluated by four Ph.D. scholars and practitioners, leading to improvements in indicator wording and a reduction in the number of indicators. The questionnaire was subsequently translated from English to Chinese, as we hypothesized that providing the questionnaire in the native language might enhance the response rate. Finally, we conducted a preliminary test of the questionnaire with several companies before proceeding with the formal survey. The data obtained from the formal survey met the measurement criteria outlined in Section 5.1.

4.2. Constructs and Measures

The application of digital platforms(DP) allows firms to utilize external information and knowledge resources for competitive advantage. In this study, the measurement of digital platform applications focuses on assessing the extent to which these platforms facilitate information exchange with partners. Based on the maturity scale proposed by Cenamor et al. (2019), the study evaluated the level of information integration achieved by firms using four distinct items.

This study utilizes the dimensions of business model innovation (BMI) proposed by Clauss (2017), which include new products, new customers/markets, new channels, new customer relationships, new capabilities, new technologies, new processes, new partnerships, new revenue models, and new cost structures. However, during the pre-test phase, it was observed that the factor loadings for new products, new customers/markets, new channels, new customer relationships, new revenue models, and new cost structures were below 0.7. Consequently, based on the research of Xie et al. (2022), the study focuses on four dimensions—new capabilities, new technologies, new partnerships, and new business processes—to measure business model innovation.

Closed-Loop Supply Chain (CLSC) encompasses a series of interconnected projects and activities within a closed-loop network designed to achieve CE objectives. This study employs the 6-item scale developed by De Giovanni (2022) to measure CLSC performance. Drawing on the work of Corona et al. (2019) and Kristensen and Mosgaard (2020), the study uses six core features—reduce, reuse, recycle, redesign, remanufacture, and recover—as metrics for evaluating CE performance. The degree to which these features are performed indicates the level of CE achieved by the enterprise. Measurement variables were assessed using a five-point Likert scale, where 1 represents "strongly disagree" and 5 represents "strongly agree."

To ensure the authenticity and validity of the samples, we first verified that the selected enterprises were familiar with the concept of digital platforms. Enterprises that lacked awareness of digital platform technologies were excluded from the sample. Next, by including a question, "Is your company using any of the following digital platform technologies?" we eliminated enterprises that did not use any digital platform technologies to maintain the rigor of the study. Finally, we controlled for basic characteristics of the enterprises, such as industry type, nature of the enterprise, size, and years in operation.

4.3. Data Collection

As the largest developing economy in the world, China is a major manufacturing hub with numerous enterprises that can impact the environment. In 2008, China incorporated CE into the strategic goal of national development (Farooque et al., 2022; Liu et al., 2023; McDowall et al., 2017). At the same time, the development and application of digital platforms in China are also relatively mature (Ha et al., 2023). Therefore, selecting enterprises from the China Circular Economy Association as samples is a highly appropriate choice. The survey was conducted between August 2023 and January 2024.

In conducting the survey, we requested respondents to voluntarily provide their contact information to facilitate follow-up surveys and ensure careful completion of the questionnaire. A total of 458 companies were contacted via email or telephone, with 324 responding. Among these, 32 respondents reported a lack of familiarity with digital platform technologies, and 17 indicated that their companies had not adopted any of these technologies. Consequently, from the 275 valid responses, we excluded 8 samples with incomplete information and 9 samples with uniform

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numerical answers. Additionally, we discarded 15 questionnaires completed by respondents with less than one year of experience at their current company. Thus, a total of 243 sample data were used to test the research hypotheses (Table 1).

Table 1. Descriptive statistics of sample.

Enterprise ownership	Frequency	Percentage (%)	Information of interviewees		
Collective-owned	168	69.14	Position	Frequency	Percentage (%)
privately-owned	75	30.86	CEO	7	2.88
Number of employees			Production manager	38	15.64
<100	12	4.94	Purchasing manager	26	10.70
100-500	72	29.63	Product manager	54	22.22
500-1000	82	33.74	R&D manager	27	11.11
1000-2000	53	21.81	Marketing manager	37	15.23
>2000	24	9.88	Assistant to manager	37	15.23
Years			others	17	7.00
<5	19	7.82	Age		
5-10	195	80.25	<30	31	12.76
>10	29	11.93	30-35	108	44.44
Industry			36-40	52	21.40
Food, beverage and alcohol	31	12.76	41-45	37	15.23
Textiles and apparel	18	7.41	46-50	11	4.53
Wood and furniture	11	4.53	>50	4	1.65
Publishing and printing	8	3.29	Working experience		
stationery and sporting	19	7.82	<3	59	24.28
Chemicals and petrochemicals	11	4.53	3-10	164	67.49
Pharmaceutical and medical	6	2.47	>10	20	8.23
Rubber and plastics	5	2.06	Gender		
Building materials	6	2.47	Male	137	56.38
Metal, mechanical and engineering	7	2.88	Female	106	43.62
Electronic and communication equipment	35	14.40	Education		
General equipment	27	11.11	College or below	21	8.64
Professional equipment	40	16.46	bachelor	141	58.03
Vehicles and equipment	19	7.82	Master or above	81	33.33

Geography	East Region	North Region	Central Region	South Region	Southwest Region	Northwest Region	Northeast Region

Frequency	74	19	37	45	18	35	15
Percentage (%)	30.45	7.82	15.23	18.52	7.41	14.40	6.17

To assess our proposed structural model, we first evaluated the measurement model and reported the relevant indicators according to recommended standards. Next, we assessed the structural model and tested the hypotheses through path analysis and bootstrap procedures.

4.4. Assessing Respondent Bias

To assess non-response bias, we evaluated samples collected at different times. Independent sample tests were performed on control variables, such as organizational size, as well as on key independent variables in the model. No significant differences were found, indicating that non-response bias was not a major concern in this study.

The research design addressed common method bias (CMB) using several strategies. First, the questionnaire was organized to avoid reflecting the model order depicted in Figure 4, thereby minimizing potential bias in the tested relationships. Second, measurement questions for each construct were spread across different sections to prevent respondents from deducing causal relationships. Third, multiple statistical techniques were employed to test for CMB. The common latent factor technique, with a linear estimate of 0.236, was below the threshold of 0.500. Furthermore, we assessed the fit indices of the common method factor model, the study model, and the model with the common method factor (Table 2). The inclusion of the common method factor did not lead to a significant improvement in model fit indices, suggesting that CMB is not a major concern. Based on the survey design and these test results, we conclude that CMB does not compromise the validity of the study data.

Table 2. Common method bias test.

Model	χ^2	*df*	χ^2/df	*CFI*	*TLI*	*RMSEA*	*SRMR*
Model 1	2144.347	170	12.614	0.397	0.326	0.219	0.203
Model 2	195.989	164	1.195	0.990	0.989	0.028	0.043
Model 3	217.300	166	1.309	0.984	0.982	0.036	0.062

Annotation: Model 1: Unifactor model; Model 2: four factor model; Model 3: five factor model.

5. Results

To answer our research question and test the model in Figure 4, a covariance-based structural equation model is employed. We chose the maximum likelihood estimation method, which provides more precise fit indices and reduces bias in parameter estimates for overlapping paths in the model. The ML estimation method assumes multivariate normality, which is validated for our data by the Doornik-Hansen test ($p > \chi^2 = 0.045$).

5.1. Measurement Model

Before estimating the measurement model, we validated the constructs using exploratory factor analysis (EFA) and confirmatory factor analysis (CFA). These analyses assessed internal consistency, composite reliability, convergent validity, and discriminant validity (see Table 3). As a result, several items were removed from the questionnaire—specifically, BMI5, BMI6, BMI7, and BMI8 for business model innovation (refer to Appendix A). This refinement enhanced the reliability and consistency of the constructs while preserving their theoretical validity.

We confirmed that Cronbach's alpha and composite reliability measures exceeded 0.7 for all constructs, indicating strong internal consistency. The numerical range of the study's average variance extracted(AVE) values ranged from 0.609 to 0.740, with greater than 0.5, thus supporting convergent validity.

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This paper uses a variety of methods to test the discriminant validity of reflective constructs. According to the Fornell-Larcker criterion, the square root of the AVE of each construct should be greater than the squared correlation between each pair of latent constructs. Our analysis confirms this (see Table 4). Additionally, we ensure that the external load of each project is greater than its cross-load. Furthermore, a further HTMT test was carried out to ensure that their values did not exceed 0.85(Table 5). These results validate the adequacy of the measurement items used in our analysis, allowing us to proceed with evaluating the structural model.

Table 3. Construct measurement, validity, and reliability.

Constract	Label	Factor Loading	Cronbach's alpha	Composite Reliability	Average Extracted	Variance
Digital platforms	DP1	0.971	0.853	0.951	0.609	
	DP2	0.697				
	DP3	0.720				
	DP4	0.700				
Business model innovation	BMI1	0.909	0.919	0.973	0.740	
	BMI2	0.815				
	BMI3	0.875				
	BMI4	0.838				
Closed-Loop Supply Chain	CLSC1	0.961	0.912	0.963	0.650	
	CLSC2	0.783				
	CLSC3	0.787				
	CLSC4	0.776				
	CLSC5	0.755				
	CLSC6	0.756				
Circular economy	CE1	0.970	0.916	0.963	0.643	
	CE2	0.786				
	CE3	0.769				
	CE4	0.754				
	CE5	0.713				
	CE6	0.795				

Goodness of fit: χ^2=195.989; df=164; χ^2/df=1.195; CFI=0.990; TLI=0.989; RMSEA=0.028; SRMR=0.043.

Table 4. Correlation matrix.

Variable	Mean	Std. dev.	1	2	3	4	5	6	7	8
Digital platforms	3.630	0.782	0.780							
Business model innovation	3.552	0.882	0.241***	0.860						
Closed-Loop Supply Chain	3.279	0.826	0.348***	0.138*	0.806					
Circular economy	4.032	0.837	0.209**	0.352***	0.348***	0.802				
Industry	-	-	0.039	0.051	0.009	0.149*				
Enterprise ownership	-	-	0.008	0.047	0.001	0.082	-0.082			
Number of employees	-	-	0.426***	0.349***	0.429***	0.380***	0.050	0.098		

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Years	-	-	0.229**	0.269***	0.269***	0.291***	0.226**	-0.039	0.316***

Annotation: squared value of the AVE reported on the diagonal; *p < 0.05; **p < 0.01; ***p < 0.001.

Table 5. HTMT test.

	1	2	3	4
Digital platforms	-			
Business model innovation	0.594	-		
Closed-Loop Supply Chain	0.344	0.401	-	
Circular economy	0.324	0.609	0.605	-

5.2. Model Testing

We tested the structural model by CB-SEM path analysis using Stata 17. Table 6 presents the structural model results, including standardized path coefficients, with two-tailed tests to determine the significance of the hypotheses. The structural model fitted the data well (χ^2 *=337.096;* χ^2/df*=1.195; CFI=0.971; TLI=0.967; RMSEA=0.041; SRMR=0.069*). Among the control variables, industry type (*coef.= 0.116, p < 0.05*) and enterprise size (*coef.= 0.160, p < 0.05*) positively affect CE.

Table 6. Model analysis results.

	Coef.	*Std.Err.*	*z*	*P>∣z∣*	*[95% conf. interval]*
Digital platforms —> Business model innovation	0.322	0.063	5.15	0.000	[0.200, 0.445]
Digital platforms —> Closed-Loop Supply Chain	0.392	0.059	6.63	0.000	[0.276, 0.508]
Business model innovation —> Circular economy	0.257	0.064	4.01	0.000	[0.131, 0.382]
Closed-Loop Supply Chain —> Circular economy	0.254	0.066	3.83	0.000	[0.124, 0.384]
Industry —> Circular economy	0.116	0.059	1.97	0.048	[0.000, 0.232]
Enterprise ownership —> Circular economy	0.052	0.058	0.89	0.373	[-0.062, 0.166]
Number of employees —> Circular economy	0.160	0.069	2.30	0.021	[0.024, 0.296]
Years —> Circular economy	0.088	0.065	1.35	0.177	[-0.040, 0.215]

Goodness of fit: χ^2=337.096; df=238; χ^2/df=1.195; CFI=0.971; TLI=0.967; RMSEA=0.041; SRMR=0.069.

Consistent with H1 and H2, the better the application of enterprise digital platforms is, the better the performance of business model innovation(*coef.= 0.322, p < 0.001*) and closed-loop supply chain(*coef.= 0.392, p < 0.001*) will be. Higher business model innovation(*coef.= 0.257, p < 0.001*) and closed-loop supply chain(*coef.= 0.254, p < 0.001*) were associated with higher CE, and H3 and H5 were accepted. In support of hypotheses H4 and H6, we observe a positive correlation between digital platforms and CE(*β= 0.209, p < 0.01*).

To verify the significance of the mediating effect of business model innovation and closed-loop supply chain in the relationship between digital platforms and CE, we used bootstrapping (2000) analysis to evaluate the indirect effect of digital platforms and CE. Mediation is confirmed if the derived confidence interval does not contain zero. The results are reported in Table 7.

Table 7. Bootstrapping test.

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	Coef.	std. err.	z	P>|z|	[95% conf. interval]
Indirect effect of digital platforms					
Business model innovation	0.082	0.024	3.39	0.001	[0.035, 0.130]
Digital platforms	0.141	0.067	2.10	0.036	[0.010, 0.274]
Indirect effect of closed-loop supply chain					
Closed-Loop Supply Chain	0.117	0.032	3.61	0.000	[0.053, 0.180]
Digital platforms	0.107	0.076	1.41	0.159	[-0.042, 0.257]

The mediation test shows that the indirect effect of digital platforms on CE through business model innovation (*coef.= 0.082, p= 0.001*) and closed-loop supply chain(*coef.= 0.117, p= 0.000*) is statistically significant, and the confidence interval after bootstrapping does not include 0. Therefore, hypotheses H4 and H6 are supported.

6. Discussion

While a connection between digital platforms and the advancement of CE has been established, the specifics of how digital platforms can aid enterprises in achieving circular development remain unclear (Di Maria et al., 2022; Rosa et al., 2020). This study aims to elucidate how digital platforms influence CE through the value creation system. Our main objective is to explain the impact of digital platforms on CE via the mediation of the value creation system. The results indicate that improved business model innovation and more effective closed-loop supply chain practices are linked to enhanced CE within the value-creation system. Furthermore, the study identifies that both business model innovation and closed-loop supply chains mediate the relationship between digital platforms and CE. These findings provide valuable insights into the theoretical understanding of how digital platforms can support CE, contributing significantly to the existing literature on CE.

6.1. Theoretical Contribution

Digital platforms serve as a channel for information exchange between supply chain partners and are a major source of external information. They supplement the external supply chain information (Li et al., 2020), and can advance the CE of manufacturing enterprises. Achieving CE requires a timely response to internal and external market information, and such comprehensive information may not always be gathered within the company. This implies that a company may not be able to achieve CE independently and requires collaboration with other partners (Chiu and Lin, 2022). Consequently, the CE development model demands that the diverse information of the enterprise supply chain is leveraged innovatively and that it aligns with the strategic consensus among supply chain partners. In other words, achieving CE involves not only gathering diverse information from supply chain members to foster innovation but also forming strategic consensus and resource complementarity with partners.

Firstly, unlike previous studies that have explored the impact of digital platforms on CE from a dynamic capabilities perspective, this paper elucidates and demonstrates the critical role of the value creation system. This advancement is crucial because firms in developing countries are usually constrained by resources and capabilities in realizing CE. Starting from the two aspects of the ability and relationship of the value creation process, this paper discusses the principle of business model transformation and closed-loop supply chain as the ability and relationship respectively to create the performance value of CE. It is discussed that the principle of creating performance value of CE consists of business model innovation and closed-loop supply chain as capabilities and relationships respectively.

Secondly, business model innovation and closed-loop supply chain are identified as integral components of the value creation system, thereby broadening the scope of value creation in the context of CE. To achieve sustainable social development, various industries are gradually moving

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towards the development mode of eco-industrial parks. By incorporating closed-loop supply chains as a key element of the value creation system, this paper extends value creation beyond the firm. Since Porter proposed the concept of a value chain, closed-loop supply chains have emerged as crucial models for value creation (Triguero et al., 2022). The closed-loop supply chain is an indispensable and unavoidable mode of production and operation for enterprises to pursue the development of CE. It is also worth mentioning that when enterprises carry out CE-oriented business model innovation, they have to join the closed-loop supply chain as a mode of material and value transmission. It can be said that closed-loop supply chains are both a mode of creating CE value and an unavoidable pathway for realizing CE.

Finally, by elucidating the mechanism of business model innovation and closed-loop supply chain in the relationship between digital platforms and CE, this study contributes to the existing literature on digital platforms and CE. More specifically, the findings provide evidence supporting research on business model innovation within the context of technological innovation. Although the relevant goals of CE can be achieved by using digital platforms, the inevitability of the relationship between the two is weak (Rosa et al., 2020). Business model innovation enabled by digital platform technology can inject novelty into the industrial ecosystem and enable gradual sustainability transformation, such as product recycling, renovation, and restoration. Similarly, the use of digital platforms also effectively improves the operational efficiency and benefits of a closed-loop supply chain. It not only makes the exchange of information between supply chain members more convenient. More critically, digital platforms can provide users with more real-time and accurate materials and information through integrated information, which reduces the cost and inventory loss caused by incomplete information in forward and reverse supply chains. Therefore, it can be said that business model innovation and closed-loop supply chain are pivotal factors for CE that enterprises try to achieve through technological innovation.

At the same time, our data results also confirm our conjecture, that is, when business model innovation and closed-loop supply chain exist, digital platforms will play a better role in promoting the performance of CE. Therefore, it is reasonable and effective to regard business model innovation and business model innovation as two key factors that constitute a firm's value creation system and study their key role in creating CE value. This paper contributes to the literature in the field of digital platforms and CE research by providing a new perspective on how firms can achieve circular and sustainable development in the context of current resources.

6.2. Practical Significance

Our findings suggest that DPs are important resources for CE and that the value creation system is a key factor for CE's success. This finding is important for managers, which can help developing country firms achieve their CE goals. For example, previous research has shown that digital platforms promote CE by changing the capabilities and information access of focal firms (Di Maria et al., 2022). The Internet, communications, and computer revolutions are slowly eating away at the traditional model of development, and executives have to recognize and accept these new realities. Many enterprises turn to technology investment and neglect the coordination adjustment of value creation systems, which leads to failure.

The conclusion is critical to the management transformation value creation system. Business model innovation is a key factor in the success of CE, which is widely recognized by the industry. However, the key role of the closed-loop supply chain in the value-creation process is also worthy of attention. Closed-loop supply chains are often thought of as mere reverse product recycling. Managers often ignore the market and opportunity information they carry, as well as the impact of the reverse circulation of waste products on the distribution of positive goods (Brydges, 2021). Practitioners should pay attention to the operation of their closed-loop supply chain and the opportunities and information that are entangled in the operation of this process.

6.3. Limitations and Research Prospects

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Although this study makes significant contributions to the literature, providing valuable insights for managers and policymakers seeking to leverage the relationship between digital platforms and CE, it also has limitations.

The study highlighted the crucial role of business model innovation as a capability within the relationship but did not address the implementation process or the potential challenges of business model innovation with the help of digital platforms. This is an important area of concern. Future research should deepen the discussion on the nature of how to transform business models for CE. This will help us to have a deeper understanding of business model transformation or circular business model in the context of CE.

This study demonstrates the significant contributions of business model innovation and closed-loop supply chains within the value-creation process, focusing on only two elements. Future research could also expand the current analysis by further considering specific technologies and activities within the value chain. In addition, the study discussed the role of business model innovation as a capability in the relationship, without discussing its implementation and the challenges that business model innovation may encounter with the help of digital platforms. This is a matter of concern.

In addition, the sample used in the study only represents the characteristics of enterprises in China, a developing country, which has certain limitations of geographical and regional economic characteristics. Future research can consider using multi-country samples for analysis, which will point out a paradigm for global enterprises to refer to.

Appendix A. Construct Measurement

These items included in the questionnaire, which asked the respondent to consider the past two years as the time horizon.

Construct	Item	Label	Mean	St. dev.
Digital Platform	Easily access data from our partners' information systems	DP1	3.634	0.924
	Seamless connection between partners' IT systems and ours (e.g., forecasting, production, manufacturing, shipping, etc.)	DP2	3.663	0.914
	Exchange real-time information with partners	DP3	3.621	0.939
	Easily aggregate relevant information (e.g., operational information, business customer performance, cost information, etc.) from partners' databases	DP4	3.601	0.980
Business Model Innovation	Continuously training employees to reflect, build, and develop new capabilities to meet market needs	BMI1	3.564	1.004
	Updating technology regularly and taking advantage of new technology opportunities to expand product and service portfolios	BMI2	3.568	0.961
	Searching for new partners and integrating them into the process to exploit new opportunities	BMI3	3.506	0.997
	Significantly improving enterprise business management and product manufacturing processes	BMI4	3.572	0.974
	Providing more innovative products and services than competitors, and regularly solving new and unmet customer needs	BMI5	3.498	0.929
	Constantly looking for new customer segments, conducting market segmentation regularly, and seizing opportunities	BMI6	3.535	0.915
	Updating and changing the distribution channel mix regularly to improve the efficiency of channel functions	BMI7	3.646	0.866

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	Emphasis on innovating products, services, and practices to increase customer retention	BMI8	3.498	0.859
	Developping new revenue opportunities (e.g., add-on sales) to supplement or replace current revenue sources with long-term stable revenue (e.g., leasing)	BMI9	3.176	0.982
	Seeking cost savings, revising product prices regularly and taking advantage of opportunities arising from price differences	BMI10	3.872	0.916
Closed-loop Supply Chain	Starting the recovery operation	CLSC1	3.313	0.984
	Investing in the return of items involved in renovation and remanufacturing	CLSC2	3.288	0.953
	Improving the information system for tracking returns	CLSC3	3.263	1.019
	Using professional third-party logistics to obtain returns	CLSC4	3.185	0.951
	Providing exchange to consumers	CLSC5	3.313	1.025
	Offering cheap return options	CLSC6	3.313	0.975
Circular Economy	Reducing the use of water, energy, materials	CE1	4.045	1.001
	Reusing material or waste within and outside the company	CE2	4.074	0.968
	Using predominantly renewable energy	CE3	4.074	1.010
	Designing products that are easier to maintain	CE4	4.082	0.980
	Cooperates with suppliers to establish closed loops that maximize resource utilization and minimize waste	CE5	3.967	1.048
	Cooperates with consumers to establish closed loops that maximize resource utilization and minimize waste	CE6	3.947	1.021

References

1. Ahmed, A., Bhatti, S.H., Gölgeci, I., Arslan, A., 2022. Digital platform capability and organizational agility of emerging market manufacturing SMEs: The mediating role of intellectual capital and the moderating role of environmental dynamism. Technol Forecast Soc Change. 177, 121513. https://doi.org/10.1016/j.techfore.2022.121513.
2. Ancillai, C., Sabatini, A., Gatti, M., Perna, A., 2023. Digital technology and business model innovation: A systematic literature review and future research agenda. Technol Forecast Soc Change. 188, 122307. https://doi.org/10.1016/j.techfore.2022.122307.
3. Barney, J.B., Ketchen, D.J., Wright, M., 2021. Resource-Based Theory and the Value Creation Framework. J Manage. 47, 1936-55. https://doi.org/10.1177/01492063211021655.
4. Braungart, M., McDonough, W., Bollinger, A., 2007. Cradle-to-cradle design: creating healthy emissions – a strategy for eco-effective product and system design. J Clean Prod. 15, 1337-48. https://doi.org/10.1016/j.jclepro.2006.08.003.
5. Braz, A.C., Marotti De Mello, A., 2022. Circular economy supply network management: A complex adaptive system. Int J Prod Econ. 243, 108317. https://doi.org/10.1016/j.ijpe.2021.108317.
6. Broekhuizen, T.L.J., Emrich, O., Gijsenberg, M.J., Broekhuis, M., Donkers, B., Sloot, L.M., 2021. Digital platform openness: Drivers, dimensions and outcomes. J Bus Res. 122, 902-14. https://doi.org/10.1016/j.jbusres.2019.07.001.
7. Brydges, T., 2021. Closing the loop on take, make, waste: Investigating circular economy practices in the Swedish fashion industry. J Clean Prod. 293, 126245. https://doi.org/10.1016/j.jclepro.2021.126245.
8. Carayannis, E.G., Sindakis, S., Walter, C., 2015. Business Model Innovation as Lever of Organizational Sustainability. The Journal of Technology Transfer. 40, 85-104. https://doi.org/10.1007/s10961-013-9330-y.
9. Cenamor, J., Parida, V., Wincent, J., 2019. How entrepreneurial SMEs compete through digital platforms: The roles of digital platform capability, network capability and ambidexterity. J Bus Res. 100, 196-206. https://doi.org/10.1016/j.jbusres.2019.03.035.
10. Centobelli, P., Cerchione, R., Vecchio, P.D., Oropallo, E., Secundo, G., 2022. Blockchain technology for bridging trust, traceability and transparency in circular supply chain. Inf Manage. 59, 103508. https://doi.org/10.1016/j.im.2021.103508.
11. Chandna, V., 2022. Social entrepreneurship and digital platforms: Crowdfunding in the sharing-economy era. Bus Horiz. 65, 21-31. https://doi.org/10.1016/j.bushor.2021.09.005.

Preprints.org (www.preprints.org) | NOT PEER-REVIEWED | Posted: 29 November 2024 doi:10.20944/preprints202411.2338.v1

12. Clauss, T., 2017. Measuring business model innovation: conceptualization, scale development, and proof of performance. R&D Management. 47, 385-403. https://doi.org/10.1111/radm.12186.
13. Codini, A.P., Abbate, T., Messeni Petruzzelli, A., 2023. Business Model Innovation and exaptation: A new way of innovating in SMEs. Technovation. 119, 102548. https://doi.org/10.1016/j.technovation.2022.102548.
14. Corona, B., Shen, L., Reike, D., Rosales Carreón, J., Worrell, E., 2019. Towards sustainable development through the circular economy—A review and critical assessment on current circularity metrics. Resources, Conservation and Recycling. 151, 104498. https://doi.org/10.1016/j.resconrec.2019.104498.
15. De Giovanni, P., 2022. Leveraging the circular economy with a closed-loop supply chain and a reverse omnichannel using blockchain technology and incentives. Int J Oper Prod Manage. 42, 959-94. https://doi.org/10.1108/IJOPM-07-2021-0445.
16. de Reuver, M., Sørensen, C., Basole, R.C., 2018. The Digital Platform: A Research Agenda. J Inf Technol. 33, 124-35. https://doi.org/10.1057/s41265-016-0033-3.
17. Di Maria, E., De Marchi, V., Galeazzo, A., 2022. Industry 4.0 technologies and circular economy: The mediating role of supply chain integration. Bus Strategy Environ. 31, 619-32. https://doi.org/10.1002/bse.2940.
18. Farooque, M., Zhang, A., Liu, Y., Hartley, J.L., 2022. Circular supply chain management: Performance outcomes and the role of eco-industrial parks in China. Transportation Research Part E: Logistics and Transportation Review. 157, 102596. https://doi.org/10.1016/j.tre.2021.102596.
19. Ferasso, M., Beliaeva, T., Kraus, S., Clauss, T., Ribeiro Soriano, D., 2020. Circular economy business models: The state of research and avenues ahead. Bus Strategy Environ. 29, 3006-24. https://doi.org/10.1002/bse.2554.
20. Figge, F., Thorpe, A.S., 2023. Circular economy, operational eco-efficiency, and sufficiency. An integrated view. Ecol Econ. 204, 107692. https://doi.org/10.1016/j.ecolecon.2022.107692.
21. Figge, F., Thorpe, A.S., Good, J., 2021. Us before me: A group level approach to the circular economy. Ecol Econ. 179, 106838. https://doi.org/10.1016/j.ecolecon.2020.106838.
22. Freudenreich, B., Lüdeke-Freund, F., Schaltegger, S., 2020. A Stakeholder Theory Perspective on Business Models: Value Creation for Sustainability. J Bus Ethics. 166, 3-18. https://doi.org/10.1007/s10551-019-04112-z.
23. Geissdoerfer, M., Morioka, S.N., de Carvalho, M.M., Evans, S., 2018. Business models and supply chains for the Circular Economy. J Clean Prod. 190, 712-21.
24. Geng, Y., Sarkis, J., Bleischwitz, R., 2019. How to globalize the circular economy. Nature. 565, 153-55.
25. Genovese, A., Ponte, B., Cannella, S., Dominguez, R., 2023. Empowering the transition towards a circular economy through empirically-driven research: Past, present, and future. Int J Prod Econ. 258, 108765. https://doi.org/10.1016/j.ijpe.2022.108765.
26. Goltsos, T.E., Ponte, B., Wang, S., Liu, Y., Naim, M.M., Syntetos, A.A., 2019. The boomerang returns? Accounting for the impact of uncertainties on the dynamics of remanufacturing systems. Int J Prod Res. 57, 7361-94. https://doi.org/10.1080/00207543.2018.1510191.
27. Gomes, L.A.D.V., Faria, A.M.D., Braz, A.C., Mello, A.M.D., Borini, F.M., Ometto, A.R., 2023. Circular ecosystem management: Orchestrating ecosystem value proposition and configuration. Int J Prod Econ. 256, 108725. https://doi.org/10.1016/j.ijpe.2022.108725.
28. Govindan, K., Salehian, F., Kian, H., Hosseini, S.T., Mina, H., 2023. A location-inventory-routing problem to design a circular closed-loop supply chain network with carbon tax policy for achieving circular economy: An augmented epsilon-constraint approach. Int J Prod Econ. 257, 108771. https://doi.org/10.1016/j.ijpe.2023.108771.
29. Govindan, K., Soleimani, H., Kannan, D., 2015. Reverse logistics and closed-loop supply chain: A comprehensive review to explore the future. Eur J Oper Res. 240, 603-26. https://doi.org/10.1016/j.ejor.2014.07.012.
30. Grafström, J., Aasma, S., 2021. Breaking circular economy barriers. J Clean Prod. 292, 126002. https://doi.org/10.1016/j.jclepro.2021.126002.
31. Ha, S., Park, Y., Kim, J., Kim, S., 2023. Research trends of digital platforms: A survey of the literature from 2018 to 2021. Telecomm Policy. 47, 102543. https://doi.org/10.1016/j.telpol.2023.102543.
32. Ivanov, D., Dolgui, A., Sokolov, B., 2022. Cloud supply chain: Integrating Industry 4.0 and digital platforms in the "Supply Chain-as-a-Service". Transportation Research Part E: Logistics and Transportation Review. 160, 102676. https://doi.org/10.1016/j.tre.2022.102676.
33. Jansen, J., Kaledinova, E., Wolter, A., 2022. The use of cloud technology for sustainable performance of international supply chains: A case study. Transportation Research Procedia. 64, 224-31. https://doi.org/10.1016/j.trpro.2022.09.027.
34. Jonkman, J., Badraoui, I., Verduijn, T., 2022. Data sharing in food supply chains and the feasibility of cross-chain data platforms for added value. Transportation Research Procedia. 67, 21-30. https://doi.org/10.1016/j.trpro.2022.12.031.

Preprints.org (www.preprints.org) | NOT PEER-REVIEWED | Posted: 29 November 2024 doi:10.20944/preprints202411.2338.v1

35. Jonsson, K., Westergren, U.H., Holmström, J., 2008. Technologies for value creation: an exploration of remote diagnostics systems in the manufacturing industry. Inf Syst J. 18, 227-45. https://doi.org/10.1111/j.1365-2575.2007.00267.x.
36. Jovanovic, M., Sjödin, D., Parida, V., 2022. Co-evolution of platform architecture, platform services, and platform governance: Expanding the platform value of industrial digital platforms. Technovation. 118, 102218. https://doi.org/10.1016/j.technovation.2020.102218.
37. Kirchherr, J., Reike, D., Hekkert, M., 2017. Conceptualizing the circular economy: An analysis of 114 definitions. Resources, Conservation and Recycling. 127, 221-32. https://doi.org/10.1016/j.resconrec.2017.09.005.
38. Korhonen, J., Honkasalo, A., Seppälä, J., 2018. Circular Economy: The Concept and its Limitations. Ecol Econ. 143, 37-46. https://doi.org/10.1016/j.ecolecon.2017.06.041.
39. Kristensen, H.S., Mosgaard, M.A., 2020. A review of micro level indicators for a circular economy – moving away from the three dimensions of sustainability? J Clean Prod. 243, 118531. https://doi.org/10.1016/j.jclepro.2019.118531.
40. Liu, S., Wen, X., Chen, X., 2023. Circular economy policy and enterprises'environmental performance: Booster or stumbling block? China Journal of Econamics. 10, 175-210.
41. Lüdeke Freund, F., Gold, S., Bocken, N.M.P., 2019. A Review and Typology of Circular Economy Business Model Patterns. J Ind Ecol. 23, 36-61. https://doi.org/10.1111/jiec.12763.
42. McDowall, W., Geng, Y., Huang, B., Barteková, E., Bleischwitz, R., Türkeli, S., Kemp, R., Doménech, T., 2017. Circular Economy Policies in China and Europe. J Ind Ecol. 21, 651-61. https://doi.org/10.1111/jiec.12597.
43. Moraga, G., Huysveld, S., Mathieux, F., Blengini, G.A., Alaerts, L., Van Acker, K., de Meester, S., Dewulf, J., 2019. Circular economy indicators: What do they measure? Resources, Conservation and Recycling. 146, 452-61. https://doi.org/10.1016/j.resconrec.2019.03.045.
44. Nikolaou, I.E., Jones, N., Stefanakis, A., 2021. Circular Economy and Sustainability: the Past, the Present and the Future Directions. Circular Economy and Sustainability. 1, 1-20. https://doi.org/10.1007/s43615-021-00030-3.
45. Oliveira-Dias, D.D., Maqueira-Marin, J.M., Moyano-Fuentes, J., Carvalho, H., 2023. Implications of using Industry 4.0 base technologies for lean and agile supply chains and performance. Int J Prod Econ. 262, 108916. https://doi.org/10.1016/j.ijpe.2023.108916.
46. Patwa, N., Sivarajah, U., Seetharaman, A., Sarkar, S., Maiti, K., Hingorani, K., 2021. Towards a circular economy: An emerging economies context. J Bus Res. 122, 725-35. https://doi.org/10.1016/j.jbusres.2020.05.015.
47. Rohn, D., Bican, P.M., Brem, A., Kraus, S., Clauss, T., 2021. Digital platform-based business models – An exploration of critical success factors. J Eng Technol Manage. 60, 101625. https://doi.org/10.1016/j.jengtecman.2021.101625.
48. Rosa, P., Sassanelli, C., Urbinati, A., Chiaroni, D., Terzi, S., 2020. Assessing relations between Circular Economy and Industry 4.0: a systematic literature review. Int J Prod Res. 58, 1662-87.
49. Schenkel, M., Caniëls, M.C.J., Krikke, H., van der Laan, E., 2015. Understanding value creation in closed loop supply chains – Past findings and future directions. J Manuf Syst. 37, 729-45. https://doi.org/10.1016/j.jmsy.2015.04.009.
50. Sedera, D., Lokuge, S., Grover, V., Sarker, S., Sarker, S., 2016. Innovating with enterprise systems and digital platforms: A contingent resource-based theory view. Inf Manage. 53, 366-79. https://doi.org/10.1016/j.im.2016.01.001.
51. Suchek, N., Fernandes, C.I., Kraus, S., Filser, M., Sjögrén, H., 2021. Innovation and the circular economy: A systematic literature review. Bus Strategy Environ. 30, 3686-702. https://doi.org/10.1002/bse.2834.
52. Suhandi, V., Chen, P., 2023. Closed-loop supply chain inventory model in the pharmaceutical industry toward a circular economy. J Clean Prod. 383, 135474. https://doi.org/10.1016/j.jclepro.2022.135474.
53. Triguero, Á., Cuerva, M.C., Sáez Martínez, F.J., 2022. Closing the loop through eco-innovation by European firms: Circular economy for sustainable development. Bus Strategy Environ. 31, 2337-50. https://doi.org/10.1002/bse.3024.
54. Xie, X., Han, Y., Anderson, A., Ribeiro-Navarrete, S., 2022. Digital platforms and SMEs' business model innovation: Exploring the mediating mechanisms of capability reconfiguration. Int J Inf Manage. 65, 102513. https://doi.org/10.1016/j.ijinfomgt.2022.102513.
55. Zhou, S., Smulders, S., 2021. Closing the loop in a circular economy: Saving resources or suffocating innovations? Eur Econ Rev. 139, 103857. https://doi.org/10.1016/j.euroecorev.2021.103857.
56. Zott, C., Amit, R., Massa, L., 2011. The Business Model: Recent Developments and Future Research. J Manage. 37, 1019-42. https://doi.org/10.1177/0149206311406265.

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