Green Supply Chain Innovation

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Green supply chain innovation has gained significant attention from academics and practitioners due to its ability to mitigate chain liability risks, meet consumer environmental demands, and create sustainable competitive advantages. Digital technology, a valuable tool for enhancing organizational information processing capabilities, plays a crucial role in promoting successful green supply chain innovation.

digital capability advantage   green supplier learning   green customer learning

green supply chain innovation

1. Green Supply Chain Innovation

Scholars in the field of innovation have recognized that possessing innovative capabilities is crucial for organizations to introduce innovation and gain competitive advantages [1]. Green innovation (GI) also plays a crucial role in enhancing competitive advantages, and improving sustainable performance [2][3]. Green innovation emphasizes environmental protection and aims to provide environmentally friendly products [1]. Furthermore, Asiaei et al. [4] indicate that green innovation focuses on providing products, services, technologies, and management approaches that promote sustainable development and enhance sustainable performance by increasing an organization's responsiveness to environmental risks. Organizations can implement green innovation to enhance environmental performance, meet stakeholders' environmental requirements, ensure productivity, and empower competitive advantages sustainably [2].

However, competition among firms has shifted towards competition between supply chains [5]. Firms increasingly recognize that shaping a green supply chain to meet environmental requirements is crucial for sustained success. A supply chain that adds environmental value to customers is referred to as a green supply chain [1]. It purifies environmentally harmful logistics activities, reduces carbon emissions and other harmful gases, and enhances public safety in handling hazardous chemicals within the supply chain. Green supply chain innovation, an important activity to drive internal green initiatives in firms, has been proven to enhance sustainable performance by improving the efficiency of the supply chain [6]. Green supply chain innovation is an environmentally focused model that develops and manages innovative resources in supply chain operations [1]. It includes green product innovation, green process innovation, green marketing innovation, and green logistics innovation [7]. Such innovation goes beyond seeking radical changes within the supply chain (e.g., introducing novel and original products or services), and also emphasizes incremental improvements and extensions to existing products and services. Implementing green supply chain innovation can enhance companies' proactive organizational

capabilities to mitigate environmental risks and issues, reduce product life cycle burdens, and drive collaborative efforts to enhance sustainable performance.

2. Digital Capability Advantage

Disruptive digital technologies such as robotic process automation, big data, artificial intelligence, cloud computing, and blockchain are extensively utilized in supply chain strategy and operations [8][9]. Supply chains are transforming into tightly interconnected networks of digital technologies, fundamentally altering how data are collected, distributed, and processed [10]. This trend is referred to as supply chain digitization [11]. Previous studies have demonstrated the association between supply chain digitization and powerful information processing capabilities [12]. It revolutionizes the supply chain by enabling firms to flexibly and intelligently integrate more precise and granular data [11], including implementing consumer feedback [13], managing supply chain relationships [14], integrating the supply chain [15], and making data-based decisions to gain a competitive advantage [16][17]. Particularly in the context where green supply chain management has become a crucial source of sustainable competitive advantage for firms, the role of supply chain digitization is emerging. For instance, Liu et al. [18] demonstrated that big data analytics capabilities, which help organizations acquire and analyze data to generate new insights, can facilitate green supply chain integration by enhancing firms' information processing capabilities. Supply chain digitization serves as a key driver of corporate performance in green supply chain management. The concept of digital capability advantage refers to the extent to which buyers have more advanced digital capabilities than suppliers [14]. The digital capability advantage of buyers represents a versatile ability to process information that can be applied in various domains, such as customer preference analysis and demand forecasting.

However, some scholars have proposed that digital capabilities, while helping supply chains acquire and create value, also have a dark side [19]. Differences in ecological position, resource endowment, and developmental stage among supply chain partners may lead to uneven development of digital technologies among members. Uneven development of digital capabilities between buyers and suppliers can result in the emergence of new supply chain structures and relationships. Asymmetric digital capabilities create winners between buyers and suppliers, with companies in advantageous positions often generating greater value [19]. Additionally, building digital capabilities requires companies to invest resources in redesigning operational processes and organizational structures, potentially encroaching upon resources used for supply chain management and increasing vulnerability and risks [20][21].

3. Digital Capability Advantage and Green Supply Chain Innovation

By reviewing existing research on the relationship between digital capability advantage and green supply chain innovation, researchers identified gaps in the current literature. The analysis results are presented in **Table 1**. Researchers identified two gaps in the existing research on the relationship between digital capability advantage and green supply chain innovation. Firstly, the impact of digital capability advantage on green supply chain

innovation remains unclear. Existing studies have yielded inconsistent conclusions regarding the role of digital capability advantage. Some scholars argue that digital capabilities, such as big data analytics, contribute to enhancing green supply chain integration [18], environmental innovation [20][22], and reducing supplier unethical behavior [14]. On the other hand, research has also found that the digital capability advantage of buying firms can amplify opportunistic behavior and increase the risk of relationship breakdown [19]. Furthermore, current research has primarily explored the antecedents of green supply chain innovation from the perspectives of relational-specific investments and knowledge transfer, while relatively neglecting the influence of digital capabilities [7]. The enhancement of digital capability advantage strengthens firms' ability to engage in environmental innovation and supply chain management, potentially positively impacting green supply chain innovation. Therefore, it is necessary to clarify the impact of digital capability advantage on green supply chain innovation and address the gaps in the existing research. Secondly, the mechanism by which green supply chain management influences supplier environmental commitment remains unclear. Zhang et al. [14] identified the mediating role of relationship transparency in the association between digital capability advantage and supplier unethical behavior based on information processing theory. However, limited attention has been given to how digital capability advantage influences green supply chain innovation. This contributes to the ambiguity surrounding the role of digital capability advantage in green supply chain innovation and hampers the comprehensive understanding of effectively leveraging digital capabilities to drive successful green supply chain innovation. Therefore, elucidating the critical pathway through which digital capability advantage influences green supply chain innovation will help bridge this theoretical gap and enhance the body of research on green supply chain innovation.

Table 1. Research review.

Author	Topic	Sample Data	Research Methodology	Research Conclusions
Son et al. (2021) [19]	What is the impact of buyer's digital capability advantage on buyer opportunistic behavior?	125 small and medium-sized firms in Republic of Korea	Empirical research	Buyers with superior digital capabilities compared to suppliers from small and medium-sized firms, making them more vulnerable to buyer opportunism.
Liu et al. (2022) [18]	How does big data analytics capability drive green supply chain integration?	317 Chinese manufacturing firms	Empirical research	Big data analytics capability positively contributes to green internal integration, green customer integration, and green supplier integration. Additionally, green internal integration serves as a mediator in the relationship between big data analytics capability and green supplier (customer) integration.
Guo et al.	What is the impact of green digitization on	Panel data collected from Chinese listed companies and provincial	Empirical research	Green digitization significantly promotes environmental innovation, and this effect can

Author	Topic	Sample Data	Research Methodology	Research Conclusions
(2022) [22]	environmental innovation?	information (excluding Tibet) spanning the years 2012 to 2018, a total of 19,752 sample observations were included.		be achieved through the reinforcement of formal and informal institutional forces.
Xu et al. (2023) [20]	What is the impact of digital strategy and capabilities on ecological innovation?	10 Chinese manufacturing firms.	Empirical research	Digital strategy and capability play a significant role in promoting in ecological processes innovation, ecological products innovation, and ecological management innovation.
Zhang et al. (2022) [14]	How does the digital capability advantage of buying firms reduce supplier unethical behavior?	223 Chinese manufacturing firms	Empirical research	Buyers' digital capability advantage indirectly decreases supplier unethical behavior by enhancing relationship transparency.
Wu and Li (2019) [7]	Which factors influence green supply chain innovation?	187 Chinese high-tech firms	Empirical research	Relationship-specific investment and knowledge transfer have a significant positive impact on green supply chain innovation.
Al-Khatib (2022) [1]	What is the impact of big data analytics capabilities on dual green supply chain innovation?	303 Jordanian manufacturing firms	Empirical research	Big data analytics capability has a significant positive impact on both green radical supply chain innovation and green incremental supply chain innovation.

...nding [23].

...esses but also to absorb new knowledge, thereby maintaining a broader knowledge base [24]. Organizational learning involves discovering, selecting, and adapting new practices and integrating them into new firm-specific processes. Essentially, organizational learning aims to address problems in order to bridge the gap between the current state and the desired state [25]. With the emergence of knowledge boundaries, learning is no longer confined to the internal organization but extends to the external organization. Inter-organizational learning refers to the acquisition of knowledge that occurs beyond the boundaries of individuals and organizations, specifically at the interorganizational level [26]. It encourages firms to obtain diverse knowledge from external sources, playing a crucial role in both knowledge creation and application. The supply chain serves as a vital source of knowledge resources, expanding the firm's knowledge base through the provision of complementary knowledge. Supply chain learning is a cross-organizational learning behavior that describes how organizations coordinate their supply chain members to create collective knowledge [27].

Green supply chain learning, derived from supply chain learning, aims to enhance firms' environmental sustainability strategies and practices through learning behaviors, emphasizing interaction with supply chain

members, and supporting the transformative process of implementing circular economy initiatives [22][28]. Green supply chain learning facilitates the acquisition and mutual sharing of vital information between suppliers and customers on waste reduction, energy efficiency, and collaboration for building an eco-friendly supply chain [29]. Lisi et al. [28] classified green supply chain learning into two types: green supplier learning and customer learning. Green supplier learning involves collectively addressing environmental issues, acquiring environmental management capabilities, obtaining environmental protection information, and understanding suppliers' green skills and knowledge [24]. Green customer learning centers on acquiring information, knowledge, and professional skills from suppliers to drive environmental sustainability initiatives [27].

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