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Research article

The effects of digital technology application and supply chain management on corporate circular economy: A dynamic capability view

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ABSTRACT

Developing circular economy capability has emerged as an effective response to environmental pressures on firms. The proliferation of digital technology has created uncertainty in developing corporate circular economy capability. Although research has begun to focus on the impact of digital technology application on corporate circular economy capability, empirical evidence remains absent. Simultaneously, few studies have concerned corporate circular economy capability obtained from supply chain management. The answer to the correlation between digital technology application, supply chain management, and circular economy capability is unavailable in current research. Based on a dynamic capability view, we investigate how digital technology application affects corporate circular economy capability through supply chain management regarding supply chain risk management, collaboration, and integration. This underlying mechanism was verified with 486 Chinese-listed industrial firms and the mediating model. The findings demonstrate that digital technology application and supply chain management significantly affect corporate circular economy capability. The mediating channel whereby the digital technology application provides circular economy capability can facilitate the positive impact of supply chain risk management and collaboration while undermining the adverse effects of supply chain integration. These mediating channels differentiate in heterogeneous growth firms and are more pronounced in low-growth groups. It presents an opportunity to use digital technology to reinforce the positive impact of supply chain risk management and collaboration and mitigate the negative effect of supply chain integration on circular economy capability.

1. Introduction

In a global era of economy and trade, how corporations can actively and innovatively participate in the competitive marketplace in response to infinitely diverse customer needs, highly individual technical requirements, and rapidly changing policy demands is a strategic challenge that has long troubled academics and managers. Firms must develop the **dynamic capability (DC)** to integrate and reconfigure their resources to maintain sustainable competitive advantages (Yuan and Cao, 2022). **DC** is conducive to proactive adaptation to varying market conditions and provides firms with advanced benefits, which has become a strategic prerequisite for maintaining, enhancing, and creating corporate dynamic competitive advantages (Teece, 2007). Nevertheless, prior research on **DC** has primarily focused on financial performance to the exclusion of environmental sustainability. The negative impact of corporations on environmental sustainability is increasingly evident (Dagestani and Qing, 2022; He et al., 2022). Firms consume 90% of global resources and contribute more than 50% of global greenhouse gases, increasing environmental pressures in their operations (Calzolari et al., 2022). Accordingly, corporate **DC** in environmental sustainability has drawn extensive attention from academics and managers. In a global context of unprecedented urgency to combat climate change and environmental pollution (He et al., 2022), the **circular economy (CE)** presents a new perspective on corporate production and operation (Palea et al., 2023). **CE** is an economic growth model with the high-efficiency utilization and recycling of resources as its essential characteristics, following the concept of sustainable development (Luthra et al., 2022). Applying the **CE** to corporate productive operations can effectively utilize and integrate resources and incorporate environmental factors into their management. Developing **circular economy capability (CEC)** is an essential expression of a dynamic ability to improve the environmental sustainability of an enterprise.

Increasing commercial competition has also established strong partnerships between corporations and their **supply chain (SC)** participants to improve their **DC** through **SC** cooperation. The sharing and

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Abbreviations

(DC)	Dynamic Capability
(CE)	Circular Economy
(CEC)	Circular Economy Capability
(SC)	Supply Chain
(SCDC)	Supply Chain Dynamic Capability
(SCM)	Supply Chain Management
(SCRM)	Supply Chain Risk Management
(SCC)	Supply Chain Collaboration
(SCI)	Supply Chain Integration
(**DTA**)	Digital Technology Application

utilization of **DC** by multiple **SC** participants enable **SC** as a group to react faster to change and be more adaptive, thus creating better corporate **DC**. In addition, **SC** is an inherently dynamic process, with logistics, information, and capital flows moving between different participants to meet requirements and maximize the benefits of each (Ur Rehman et al., 2022). Thus, strengthening **supply chain management (SCM)** can improve **supply chain dynamic capacity (SCDC)** and may also enhance corporate **DC** in **SC**. Previous research on **DC** has primarily concentrated on acquiring **DC** within a single firm, and their focus can be characterized in two directions. The first is the influential factors of **DC**. Ali et al. (2022) unveiled the black box that COVID-19 and similar unknown events impact the construction of corporate **DC**. Ye et al. (2022) confirmed that social media applications could positively benefit the agility and adaptability of firms, enhancing **DC**. Bağış et al. (2022) investigated that factors, i.e., managers' attitudes and experience, social capital and networks, and organizational management structures and processes, are micro-foundations that influence **DC**. The second is the economic aftermath of **DC**. Mahmud et al. (2020) proposed using **DC** to align companies with market demand and consumer expectations while integrating internal resources to save time adapting business practices. According to Liu et al. (2020), implementing **DC** in firms can help alleviate the adverse impact of product innovation on sustainability by addressing resource inadequacy. Similarly, Abou-Foul et al. (2023) discovered that fostering **DC** can moderate the role of artificial intelligence (**AI**) on servitization and provide firms with a competitive edge.

SC in modern commercial society continues to generate new and large amounts of data, which can be utilized to maximize **SC** value and enhance **SCM**, thereby improving **SCDC**. Thus, many enterprises are embracing digital technology in the **SC**. Nevertheless, as research on the relationship between **digital technology application (DTA)** and **SCM**, controversy has emerged from the conclusions formed. Some academics favor **DTA** benefiting **SCM** because it increases reliability between firms in the **SC**, facilitates information sharing, and enhances information traceability. Behnke and Janssen (2020) proved that **DTA** enables information visualization throughout the entire food process from production to sale, helping to establish a chain-wide food quality and safety traceability system to ensure food safety. Jiang et al. (2022) revealed that **DTA**'s information integration function could decrease opportunistic behavior of information distortion and deception among members. Other academics argue that **DTA** may be detrimental to **SCM**. **DTA** can crowd out resources for creating **SCM**. **DTA** requires companies to invest resources in redesigning operational processes and organizational structures in their **SC**, which may negatively affect those that lack sufficient resources (Xu et al., 2023). Simultaneously, **DTA** may also heighten the potential for commercial espionage, production leakage, and process disruption, making **SC** more vulnerable and dangerous, thereby harming **SCM** (Syed et al., 2022).

Notwithstanding the preliminary investigation of available research into the acquisition of corporate DC and the relationship between **DTA** affecting **SCM**, three aspects remain under-researched. **First**, existing analyses primarily emphasized the cultivation and enhancement of **DC** within individual firms. Nevertheless, they neglect the benefits of receiving **DC** from **SCM**, i.e., **SCDC**. **Second**, research has been beginning to understand the effects of **DTA** on corporate **DC**. The impact of **DTA** on **CEC**, an expression of corporate **DC,** has not been adequately investigated in existing research. **Third**, existing literature has more frequently debated the effects of **DTA** on **SCM** without extensive attention being paid to the actions of **SCM in** the relationship between **DTA** and corporate **CEC** because **SCM** may also affect corporate **DC**. Simultaneously, academics have not developed a unified consensus on the scope of **SCDC**. Supply chain risk management (**SCRM**), supply chain collaboration (**SCC**), and supply chain integration (**SCI**) appear frequently and receive recognition in existing research (Hong et al., 2018; Jajja et al., 2018; Matos et al., 2020). Hence, investigating the association between **DTA**, various **SCM**, and **CEC** remains to be studied more extensively.

Based on these statements, we will answer two extensive research questions.

RQ1. What is the impact of **DTA** and various **SCM** on corporate **CEC**?

RQ2. What is the relationship between**DTA**, various **SCM**, and corporate **CEC**?

Hence, we aim to answer these questions by theoretically analyzing and empirically examining the relationship between **DTA**, various **SCM**, and corporate **CEC** from the perspective of the **DC** view. Also, corporate characteristics may interfere with them, but current research has failed to focus on this perspective. Thus, the variation in different growth corporations is further explored.

The contributions consist of three points. **Firstly**, we analyze the association between **DTA**, various **SCM**, and corporate **CEC** theoretically and empirically. Our findings prove that **DTA**, **SCRM**, and **SCC** positively associate with the corporate circular economy capability. **SCI** negatively correlates to it. Our research underpins the depth of research on **DTA**, **SCM**, and corporate **CEC**. **Secondly**, empirical results substantiate that **SCRM**, **SCC**, and **SCI** partially mediate the association between **DTA** on **CEC**, revealing underlying mechanisms of how **DTA** affects corporate **CEC**. **Finally**, testing the sample in subgroups according to the level of corporate growth discovers the regularity that mediating channels of **SCRM**, **SCC**, and **SCI** are more pronounced in low-growth firms. We provide empirical evidence for various growth firms adopting differentiated strategies to enhance their **CEC**.

The remaining sections are shown below. Section 2 reports the theoretical background of **DC** and **SCDC**, and the next section presents the research hypothesis. Then, Section 4 designs the research methodology. Afterward, Section 5 describes the results and discussion. The last section discusses the conclusions, implications, and limitations.

2. Theoretical background

2.1. Corporate dynamic capability

DC is derived from the resource-based view proposed by Barney (1991). It believes that a corporation's valuable, unique, and irreplaceable resources are the sole source of competitive advantage. Nevertheless, many corporations with unique resources have failed to perform well and have even competed and failed. Exploring the reasons for this, scholars have discovered that although corporate resources are essential, the key to its success lies in its ability to use them. Hence, The resource-based view primarily explains how corporations gain a competitive advantage from their resources and capabilities but do not explain how they sustain their advantage in an unforeseen and fast-changing environment (Eisenhardt and Martin, 2000). The analysis of a corporate competitive advantage thus transitions from the resource-based view to the **DC** view. Teece (2007) defined **DC** as an organizational capability that allows corporations to create or renew resources, where corporations reallocate and upgrade existing resources as required to respond rapidly to changing market conditions. **DC** is a unique competency that corporations draw upon to generate competitive behavior, appreciate dynamic markets, motivate them to react under varying conditions, and facilitate an active match between the corporation and its environment. The **DC** view has emerged as one of the most vibrant research themes in the strategic management literature. Its concept, composition, measurement, and factors have been extensively investigated in existing studies, as shown in Table 1. Prior studies of corporate **DC** have primarily involved economic factors and neglected environmental factors. The **CE** converts waste into valuable, bio-efficient assets which can be recycled, restored, and recovered. Combining the **CE** into corporate **DC** creates the **CEC** that allows firms to adapt and change in response to the volatile changes of the operating environment and the increasing pressure of environmental protection, achieving goals such as energy and resource reduction, material and substance reuse, and waste recycling.

2.2. Supply chain dynamic capability

SCDC is established based on the **DC** view, which is based on adapting **SCM** capabilities (Hong et al., 2018). **SCDC** has been emerging briefly. Its nature remains difficult to capture, although scholars have explored its concepts and boundaries. Defee and Fugate (2010) defined **SCDC** as the capability of **SC** to change, which enables the **SC** as a whole to adapt to changes in the external environment and to effectively manage the **SC** network and resources, thus allowing the **SC** to achieve high performance and enabling the participating firms in the chain to derive sustained competitive advantage from the **SC**. Beske (2012) argues that **SC** is a complex system, and the capability available to adapt to changes in the relationships within and outside the complex system is **SCDC**. Masteika and Čepinskis (2015) define **SCDC** as strengthening **SCM** to cope with a fast-changing environment, thereby giving a sustainable competitive advantage to **SC**. Additionally, previous research has demonstrated that **SCDC** is closely related to **SCM**. Following previous studies, we identify **SCDC** as the capability of firms in the SC to perceive environmental changes through organizational learning and to continuously risk manage, coordinate and integrate internal and external resources to accommodate the rapidly changing environment. It also determines that **SCDC** in our study relates to **SCRM**, **SCC**, and **SCI**. The cultivation of **SCDC** is essentially a process of strengthening their capacity to allocate resources, and corporations in the **SC** are constantly learning and absorbing knowledge to reconfigure and transform capacity. Therefore, it is of interest that corporate **DC** is enhanced from **SCDC**.

Table 1
Study of DC.

Theme	Contents	References
Concept	DC is an important source of competitive advantage for corporations in a dynamic environment.	Teece (2007)
	DC is defined as a set of identifiable processes and practices	Eisenhardt and Martin, 2000
	DC is seen as higher-order capabilities that act as a competitive advantage by changing common capabilities	Winter (2003)
	DC is defined as those in which the corporate decision-makers can appropriately reconfigure their resources in an expected manner	Zahra et al. (2006)
composition	Integrating, constructing, and reconstructing competencies	Teece (2007)
	Integration, reconfiguration, acquisition, and release capabilities	Eisenhardt and Martin (2000)
	Absorption, adaptation, and innovation capabilities	Wang and Ahmed (2007)
	Coordination, learning, and strategic competitive response	Protogerou et al. (2012)
	Absorptive and transformative capacities	Wang et al. (2015)
	Sensing, learning, and reconfiguration capabilities	Wilhelm et al. (2015)
measure	Case Study Method	Makkonen et al. (2014)
	Questionnaire measurement method	Wilden and Gudergan (2015)
	Simulation method	Zott (2003)
Factors	Learning capabilities	Wang et al. (2015)
	Cognitive capabilities	Helfat and Peteraf (2015)
	Leadership skills	Dixon et al. (2010)

3. Hypotheses development

3.1. DTA and CEC

DTA is a practice of applying various digital tools, platforms, and systems to a particular domain, industry, or business process to deliver efficiency, innovation, growth, and improvement (Trevisan et al., 2023). It seeks to enhance **DC** through digital technology to optimize business processes, reduce production costs, expand market share, and accelerate **R&D**, enabling more efficient, flexible, and innovative operational models and commercial value (Gao et al., 2023). The inherent characteristics of digital technology assist firms in decreasing pollutant emissions, increasing energy efficiency, and promoting resource recycling (Liu et al., 2023; Wang and Shao, 2023). First, **DTA** supports firms in monitoring and managing pollutant emissions, optimizing emission processes, and controlling emission concentrations and amounts, thereby reducing their environmental impact (Shang et al., 2023). Second, **DTA** allows companies to accurately predict trends and fluctuations in energy consumption demand to scientifically and rationally arrange production. Digital management can effectively improve the efficiency of energy conversion, transport, distribution, and storage (Matthess et al., 2023). Simultaneously, It enables firms to accurately grasp consumer demand, maximize resource use, reduce production waste, save marginal costs, and lower energy intensity. Third, **DTA** facilitates firms to monitor and manage resource recovery, optimize the recycling process, and improve the efficiency and quality of recycling, thereby reusing resources (Kurniawan et al., 2023). For example, by tracking the waste recycling process through IoT technology, problems can be identified and dealt with promptly to improve the efficiency and effectiveness of waste recycling. Thus, we reasonably believe that **DTA** can boost corporate **CEC** and proposes Hypothesis 1 (**H1**).

H1. **DTA** positively correlates with **CEC**.

3.2. SCRM and CEC

SCRM describes a series of initiatives and strategies enterprises adopt to anticipate, evaluate, control, and mitigate various risks that may appear in **SC** to safeguard the normal operation of **SC** and themselves (Ur Rehman et al., 2022). Its principal objective is to reduce uncertainty and risk in **SC** and to guarantee its stability and reliability. Under the influence of **SCRM**, companies can identify and assess the potential dangers of resource wastage and waste discharge in **SC** and thus take appropriate measures to promote resource recovery and utilization (Oliveira et al., 2019). **SCRM** enables companies to identify and assess pollutant emissions from SC segments or individuals, such as waste gases, wastewater, or solid waste. After diagnosing pollutant emissions in critical parts, enterprises can formulate environmental protection plans with their suppliers to reduce them by enhancing production processes and technologies (Kim et al., 2021). It decreases the risk of polluting emissions from both **SC** and the firm itself. In addition, firms can identify and control the risks of resource recycling and assess the costs of resource reuse through **SCRM** (Appolloni et al., 2021), which is beneficial for them to reduce resource waste, control production costs, and obtain additional economic benefits. It enhances the corporate resource utilization capability. Hence, this research proposes Hypothesis 2 (**H2**).

H2. **SCRM** positively correlates with **CEC**.

3.3. SCC and CEC

SCC involves close cooperation between SC firms and parties to formulate and implement **SC** strategies and schedules to achieve resource sharing, risk sharing, and benefit sharing (Govindan et al., 2019). It emphasizes the interaction and cooperation among various parties in **SC** to achieve a win-win situation. **SCC** promotes collaboration and exchange among firms and contributes to resource recycling, use, and **CE** dissemination. Firstly, firms can maximize resource recycling by cooperating with suppliers to jointly explore technologies and solutions for recycling waste (Calicchio and de Brito, 2021). Secondly, firms also establish long-term partnerships with suppliers to co-develop new products, materials, and technologies, thus achieving resource-efficient efficiency (Calicchio and de Brito, 2021). Thirdly, enterprises can share their experiences of **CE** with **SC** partners, discuss **CE** bottlenecks, and formulate proposals for **CE** development, effectively promoting the dissemination of the **CE** concept (Sudusinghe and Seuring, 2022). As a result, **SCC** enhances the **CEC** of the **SC** while also improving the **CEC** of the individual. This research proposes Hypothesis 3 (**H3**).

H3. **SCC** positively correlates with **CEC**.

3.4. SCI and CEC

SCI can be interpreted as the integration of **SC** participants and reflect the market share and control strength among the major participants in **SC**, such as suppliers, manufacturers, wholesalers, and retailers, i.e., the degree of market competition and the distribution of market power among them (Chen et al., 2023). Excessive **SCI** may constrain firms' feasibility of fostering **CEC**. First, a handful of firms hold dominant market positions in highly integrated **SC**, which implies that firms must depend on them to achieve **CEC**, and they may not be willing or equipped to support implementing a circular economy (Liu et al., 2022). Second, firms in highly integrated **SC** may experience difficulties in accessing the development and dissemination of new technologies and products, which may constrain their innovation in **CE** (Wong et al., 2013**)**. Third, a highly integrated **SC** potentially discourages firms from improving their **CEC** by rendering them less risk-taking. The greater the **SCI**, the more dependent the corporation is on specific suppliers and the more prone the supplier's operational fluctuations to affect the corporation (Titman, 1984). Meanwhile, it also has difficulty establishing good partnerships with other companies when recycling and reusing materials. Thus, this research proposes Hypothesis 4 (**H4**).

H4. **SCI** negatively correlates with **CEC**.

3.5. Mediating effect of SCRM, SCC, and SCI

The primary function of **SCRM** is to recognize potential risk sources and investigate risk mitigation methods (Revilla and Saenz, 2017). The real-time visibility provided by the **DTA** enables a rapid response to risks of pollution emissions and resource wastage arising from potential and unpredictable events by companies in the **SC** to make new balances and rational solutions, adjusting **SC** strategies and delivery networks in time (Tao et al., 2018). Supported by powerful, standardized, and transparent data, SCRM identifies, assesses, and controls the risks of environmental pollution and resource waste while strengthening the pollution control and resource utilization capability within the companies in the **SC**.

SCC involves the collaboration of stakeholders to reduce costs, increase profits, and optimize performance, contributing to the success of **SC**, which is a strategic response to interdependence (Pettit et al., 2019). **DTA** can foster **SCC** with shared ecological systems and business networks to better products, preserve assets, serve competitive markets, and create new business models (Nguyen et al., 2022). Crucially, **DTA** increases the business network's transparency and visibility, enabling corporations and their partners to check in real-time everything that is happening with the products and assets (Ait-Alla et al., 2021). Based on **DTA**, **SCC** makes enterprises within the **SC** close to each other, accelerating the dissemination speed and efficiency regarding knowledge, technology, and patents in the **CE** and stimulating enterprises to participate in the cultivation of **CEC**.

SCI reflects the extent to which a firm relies on **SC** participants. As mentioned, excessive **SCI** can hinder the spread of knowledge and technology about **CE** among enterprises and increase the risk of developing corporate **CEC**. **DTA** empowers the supply network to run parallel versions containing the same supply entities, parameters, and finance targets (Al-Omoush et al., 2023). In this process, corporations can mitigate the adverse effects of **SCI** by switching between alternative suppliers to strengthen corporate **CEC**. As a result, companies can leverage d **DTA** to enhance the positive impact of **SCRM** and **SCC** on **CEC** and mitigate the adverse effects of **SCI** on **CEC**. This research formulates Hypothesis 5a (**H5a**), Hypothesis 5b (**H5b**), and Hypothesis 5a (**H5c**).

H5a. **SCRM** is mediating between **DTA** and **CEC.**

H5b. **SCC** is mediating between **DTA** and **CEC.**

H5c. **SCI** is mediating between **DTA** and **CEC.**

3.6. Perspective of corporate growth

The preceding analysis shows that **DTA** can influence corporate **CEC** where **SCRM**, **SCC**, and **SCI** are critical pathways. Nevertheless, enterprises possess the capacity for development, expressed as corporate growth. The scale of sale, production, and staff can demonstrate corporate growth. High-growth companies are usually above average in these indicators, while low-growth companies are below average (Patel et al., 2018; Liedong et al., 2022). Differences in corporate growth characteristics may change the relationship between **DTA**, **SCM**, and **CEC**.

High-growth and low-growth firms experience financial resource constraints, but high-growth firms are more restrained than low-growth firms (Grichnik et al., 2014). Additionally, whereas the future cash flows of high-growth firms represent more investment opportunities, these new investment opportunities are often associated with higher levels of risk and uncertainty. As a result, the **SC** of high-growth firms may be lower in their ability to endure risk than low-growth firms under the influence of financial constraints, investment risk, and uncertainty. It implies that the mediating channel of **DTA** on corporate **CEC** may be insignificant in high-growth firms. Accordingly, we stated Hypothesis 6a (**H6a**), Hypothesis 6b (**H6b**), and Hypothesis 6c (**H6c**).

H6a. The mediating channel of **SCRM** is more significant in low-growth firms.

H6b. The mediating channel of **SCC** is more significant in low-growth firms.

H6c. The mediating channel of **SCI** is more significant in low-growth firms.

Fig. 1 illustrates the logical framework of this paper.

4. Research methodology

4.1. Sample

We select A-share listed industrial firms in China as samples from 2015 to 2021. There are two selection bases. First, the industry is an essential backbone of national economic development, and industrial listed corporations account for over 60% of the market capitalization of listed firms in Chian (Ding et al., 2022), which makes the research more

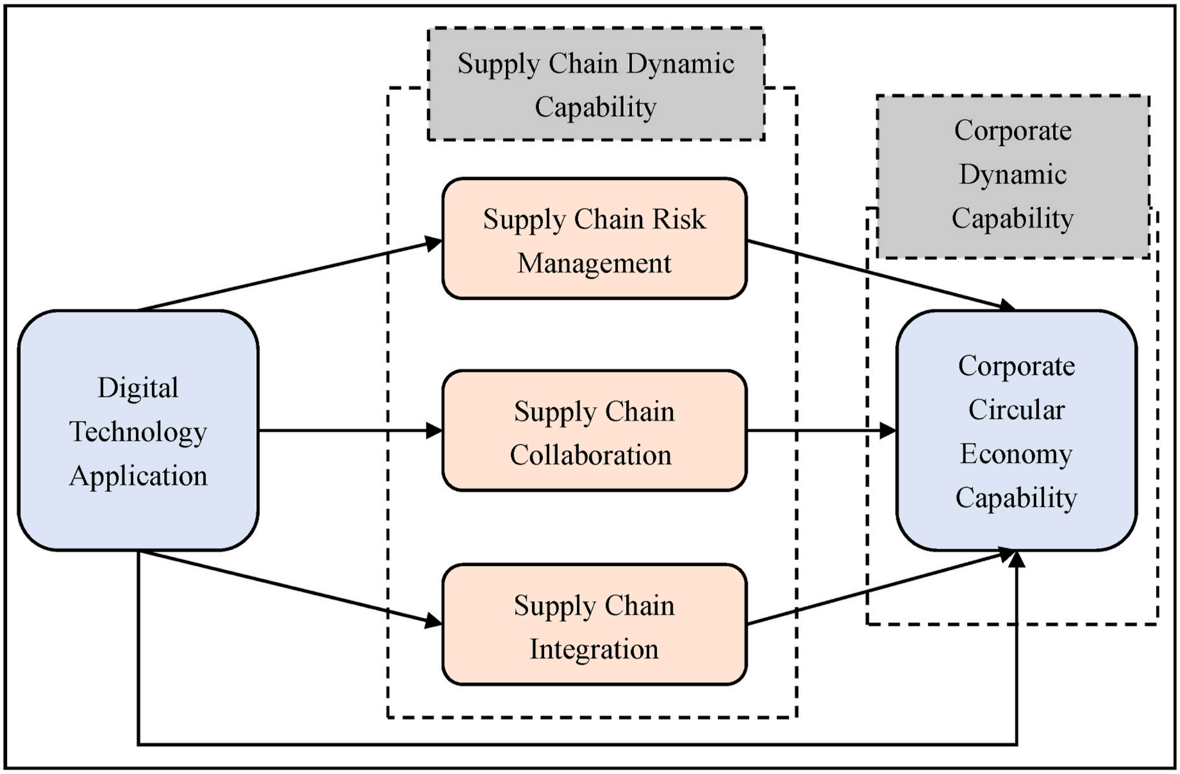

Fig. 1. The logical framework.

representative. Second, *China Securities Regulatory Commission* has issued *Administrative Measures on Information Disclosure by Listed Companies* urging them to regularly disclose information related to corporations (Gong and Marsden, 2014). It is instrumental in estimating variables by applying content analysis, and data acquisition is feasible. ST and *ST firms with continuous losses and delisting warnings are excluded. Simultaneously, those firms with significant missing data related to our variables are also dropped. Then, we removed those firms with discontinuous data within the period. Finally, our study includes 3402 observations from 486 firms. **CEC**, **SCRM**, **SCC**, and **DTA** are explored in annual reports, social responsibility reports, and news reports. Then, financial data come from CSMAR. Table 2 provides the industry distribution of the sample.

4.2. Variables

Table 3 presents details of all variables. We, following the content analysis method of Li et al. (2017), construct an evaluation system for **CEC**, **SCRM**, and **SCC**. This method applied to score the above variables can obtain more valid samples than the questionnaire method, with the specific evaluation items and descriptions shown in Table 3. It has the advantages of being easily accessible, effective, and verifiable and has been employed in research, such as Li et al. (2017), Kuo and Chang (2021), Yuan and Pan (2022), and Long et al. (2023). Kuo and Chang (2021) have used this method to measure circular economy information for Chinese firms. The calculated formulae are Model (1), Model (2), and Model (3), respectively.

$$CEC_i = \frac{\sum_{i=1}^{11} CECP_i}{CECTP} \tag{1}$$

$$SCRM_i = \frac{\sum_{i=1}^{4} SCRMP_i}{SCRMTP} \tag{2}$$

$$SCC_i = \frac{\sum_{i=1}^{4} SCCP_i}{SCCTP} \tag{3}$$

CEC_i, $SCRM_i$ and SCC_i respectively represent the corporate circular economy capacity, supply chain risk management, and supply chain collaboration. $CECP_i$ denotes the total score of **CEC** items for the *i-th* firm. $SCRMP_i$ means the total score of **SCRM** items for the *i-th* firm. *SCCP* demonstrate the total score of **SCC** items for the *i-th* firm. *CECTP*, *SCRMTP* and *SCCTP* respectively indicate the maximum score for all disclosure items in circular economy capacity, supply chain risk management, and collaboration.

DTA is hardly measurable by a single financial indicator (Chen and Kim, 2023). Nevertheless, the extent to which a firm attaches importance to a particular strategic orientation can be reflected by the frequency with which keywords related to that strategy appear in the annual report. Consequently, we obtained keyword frequency using

Table 2
Sample distribution.

Industry	Quantity	Proportion
Ferrous metal mining	12	2.47%
Coal mining and washing	19	3.91%
Non-ferrous metal mining and processing	21	4.32%
Electricity, heat production, and supply industry	29	5.97%
Textile industry	23	4.73%
Non-metallic mineral products industry	57	11.73%
Ferrous metal smelting and rolling processing industry	23	4.73%
Chemical raw material and chemical product manufacturing	16	3.29%
Wine, beverage, and refined tea manufacturing	31	6.38%
Wood processing industry	8	1.65%
Food manufacturing	4	0.82%
Pharmaceutical manufacturing	155	31.89%
Printing and recording media reproduction industry	48	9.88%
Paper and paper products industry	18	3.70%
Other industries	22	4.53%

Table 3
Variable definitions and descriptions.

Items	Descriptions	Scores	Reference
CEC	Unit product manual input reducing Energy consumption reducing Energy efficiency-enhancing Packaging materials recycling Equipment materials recycling Waste recycling in the production Waste reprocessing Waste remanufacturing Waste from customers is recycled Emission reduction targets Environmental protection planning	Qualitative disclosure is 1. Simple qualitative and quantitative disclosure is 1.5. Detailed qualitative and quantitative disclosure is 2. No disclosure is 0.	French and Laforge (2006); Zeng et al. (2017); Centobelli et al. (2021)
SCRM	Risk sharing effort SC continuity team Knowing risk Risk consideration in decision		Chowdhury and Quaddus (2016); Sharma et al. (2022)
SCC	Supply chain problem-solving Fair competition Cooperation arrangements Supply chain assistance		Mandal and Sarathy (2018); Govindan et al. (2019)
SCI	Top five suppliers combined as a percentage of total annual purchases		Liu et al. (2021)
DTA	Data management, data mining, data networks, data platforms, data centres, data science, digital control, digital technology, digital communication, digital networks, digital intelligence, digital terminals, digital marketing, digitisation, big data, cloud computing, cloud IT, cloud ecology, cloud services, cloud platforms, blockchain, Internet of Things, machine learning		Perno et al. (2022); Zhuo and Chen (2023)
ROA	Net profit/average balance of total assets		Bui et al. (2020);
COA	Number of years that the corporation has been listed		Siddique et al. (2021); Liu et al. (2023)
OPC	Total asset turnover ratio		
DSC	Net cash flow from operating activities/total liabilities		
COS	The logarithm of total assets		

Python software to represent **DTA** better because the *Jieba* module in *Python* software can automatically separate text content, extract keywords and count word frequency.

We also control for some variables, including return on total assets (*ROA*), corporate age (*COA*), operational capacity (*OPC*), debt service capacity (*DSC*), and corporate size (*COS*). These variables may change the impact of the association between **DTA**, various **SCM**, and corporate **CEC**.

Table 4 demonstrates descriptive statistics. The mean for *CEC*, *SCRM*, *SCC*, and *DTA* is lower than the median in Table 4. It reflects the lower levels of listed industrial corporate *CEC*, *SCRM*, *SCC*, and *DTA*. Additionally, the Pearson Correlation Coefficient shows that the control variables are significant at the 1% confidence level, illustrating preliminary evidence that these variables are correlated with *CEC* that requires to be controlled for.

Table 4
Descriptive statistics of variables.

Variable	Obs	Mean	Std. Dev.	Min	Max	Pearson correlation
CEC	3402	0.270	0.088	0.045	0.545	1.000
DTA	3402	1.625	2.966	0	61.000	0.090***
SCRM	3402	0.252	0.018	0.150	0.500	0.106***
SCC	3402	0.154	0.061	0.100	0.425	0.297***
SCI	3402	0.306	0.194	0.006	0.998	−0.167***
ROA	3402	0.066	0.077	−0.468	0.404	0.041**
COA	3402	13.567	7.152	0.000	29.000	0.022*
OPC	3402	0.632	0.412	0.073	3.096	0.178***
DSC	3402	0.246	0.352	−0.471	2.460	−0.056***
COS	3402	199.984	429.730	3.758	3217.385	0.231***

Note: *$p < 0.1$, **$p < 0.05$, ***$p < 0.01$.

4.3. Model

4.3.1. Baseline model

The baseline model is constructed as follows.

$$CEC_{i,t} = \alpha_0 + \alpha_1 DTA_{i,t} + \sum \alpha_k Controls_{i,t} + \mu_{region} + \mu_{year} + \mu_{industry} + \varepsilon_{i,t} \tag{4}$$

$$CEC_{i,t} = \beta_0 + \beta_1 SCRM_{i,t} + \sum \beta_k Controls_{i,t} + \mu_{region} + \mu_{year} + \mu_{industry} + \varepsilon_{i,t} \tag{5}$$

$$CEC_{i,t} = \chi_0 + \chi_1 SCC_{i,t} + \sum \chi_k Controls_{i,t} + \mu_{region} + \mu_{year} + \mu_{industry} + \varepsilon_{i,t} \tag{6}$$

$$CEC_{i,t} = \delta_0 + \delta_1 SCI_{i,t} + \sum \delta_k Controls_{i,t} + \mu_{region} + \mu_{year} + \mu_{industry} + \varepsilon_{i,t} \tag{7}$$

$$CEC_{i,t} = \alpha_0^{'} + \sum \alpha_j^{'} Core_{i,t} + \sum \alpha_k^{'} Controls_{i,t} + \mu_{region} + \mu_{year} + \mu_{industry} + \varepsilon_{i,t} \tag{8}$$

where $CEC_{i,t}$ represents corporate circular economy capacity. $DTA_{i,t}$ denotes digital technology application. $SCRM_{i,t}$, $SCC_{i,t}$ and $SCI_{i,t}$ demonstrate supply chain risk management, collaboration, and integration, respectively. $Core_{i,t}$ include simultaneously $DTA_{i,t}$, $SCRM_{i,t}$, $SCC_{i,t}$ and $SCI_{i,t}$. $Controls_{i,t}$ means control variables. μ_{region}, μ_{year} and $\mu_{industry}$ indicate region-fixed effects, year-fixed effects, and industry-fixed effects, respectively. $\varepsilon_{i,t}$ represents the error term.

4.3.2. Mediation Model

A two-step mediation model is employed to investigate how **DTA** affects **CEC**. First, Model (9) is applied to examine the **DTA** on **CEC**. If γ_1 is positive and significant, it indicates that **DTA** generates a positive impact on **CEC**.

$$CEC_{i,t} = \gamma_0 + \gamma_1 DTA_{i,t} + \sum \gamma_k Controls_{i,t} + \varepsilon_{i,t} \tag{9}$$

Second, Models (10) and (11) are adopted to examine how **DTA** affects **CEC** by **SCM**. Model (10) represents the effect of **DTA** on **SCM**, including **SCRM**, **SCC**, and **SCI**. The mediating effect of **SCM** exists, if φ_1 is significant. In Model (11), φ_1 is the direct effect of **DTA** on **CEC** after controlling for **SCM**. Similarly, φ_2 is the effect of **SCM** on **CEC** after controlling for **DTA**. Both φ_1 and φ_2 are significant, implying a partial mediating effect of **SCM**. φ_1 is insignificant, while φ_2 is significant, which means that there is a full mediating effect of **SCM**.

$$SCM_{i,t} = \varphi_0 + \varphi_1 DTA_{i,t} + \sum \varphi_k Controls_{i,t} + \varepsilon_{i,t} \tag{10}$$

$$CEC_{i,t} = \varphi_0 + \varphi_1 DTA_{i,t} + \varphi_2 SCM_{i,t} + \sum \varphi_k Controls_{i,t} + \varepsilon_{i,t} \tag{11}$$

5. Results and discussion

5.1. Baseline results

Table 5 presents the baseline results. Columns (1), (2), and (3) reveal that **DTA**, **SCRM**, and **SCC** have significant positive impacts on **CEC** ($\alpha_1 = 0.033$; $\beta_1 = 0.541$; $\chi_1 = 0.200$; $p < 0.01$). Our findings support previous investigations, such as Zeng et al. (2017), Liu et al. (2023), Yontar (2023), and Trevisan et al. (2023). They concluded that **DTA**, **SCRM**, and **SCC** enhance the corporate ability to identify risks, resist and recover from disruptions in **SC**, and contribute positively to **CEC**. Column (4) reports a significant negative contribution of **SCI** to **CEC** ($\delta_1 = -0.029$; $p < 0.01$). This result contrasts with the findings of Jajja et al. (2018) and Chen et al. (2023). They discovered that **SCI** enhanced information sharing and cooperation intensity among partners in **SC**, decreasing information asymmetry issues. According to their findings, **SCI** should have facilitated **CEC**. However, we found a negative correlation between **SCI** and **CEC**, indicating that **SCI** among listed industrial corporations in China may increase uncertainty in **CEC**. More specifically, the higher the level of **SCI**, the greater the opportunity for partners in the **SC** to obtain products at lower prices, crowding out corporate profits and increasing operating risks. Additionally, **SCI** may make supply chain partners less flexible in responding to environmental changes (Terjesen et al., 2012). Column (5) is a simultaneous regression of **DTA**, **SCRM**, **SCC**, and **SCI**, illustrating that the impact of **DTA**, **SCRM**, **SCC**, and **SCI** on **CEC** does not change significantly. Thus, H1, H2, H3, and H4 are verified.

5.2. Mediating effect results

5.2.1. SCRM

Column (1) represents a test for the total effect of the **DTA** on **CEC** in Table 6. The coefficient on **DTA** is significantly positive ($\gamma_1 = 0.051$; $p < 0.01$). Columns (2) and (3) test the mediating effect of **SCRM**. In column (2), **DTA** has a promotional impact on **SCRM** ($\varphi_1 = 0.004$; $p < 0.01$). The **DTA** employs a variety of modeling techniques. These models can be applied to predict the future state of corporations, facilitating the identification of developing risks and thus enhancing management (Tao et al., 2018; Liu et al., 2023). In column (3), **DTA** and **SCRM** significantly positively affect **CEC** ($\varphi_1 = 0.049$; $\varphi_2 = 0.485$; $p < 0.01$). Additionally, the *Sobel* test is at the 1% significance level ($p < 0.01$). It indicates a partial mediating effect of **SCRM**. Namely, **DTA** enhances **SCRM** and improves **CEC**. It supports H5a. The **DTA** visualizes the state of **SC**, including transport, inventory, and demand data, facilitating monitoring and planning by decision-makers, and improving **SCRM**, thereby contributing to **CEC**.

Table 5
Baseline results.

Variable	(1) CEC	(2) CEC	(3) CEC	(4) CEC	(5) CEC
DTA	0.033***				0.024***
	(4.15)				(3.18)
SCRM		0.541***			0.228***
		(6.83)			(2.82)
SCC			0.200***		0.184***
			(11.63)		(10.21)
SCI				−0.029***	−0.024**
				(-2.95)	(-2.49)
ROA	−0.076	−0.052	−0.059	−0.055	−0.072
	(-0.97)	(-0.67)	(-0.77)	(-0.71)	(-0.93)
COA	−0.004***	−0.005***	−0.005***	−0.004***	−0.005***
	(-5.08)	(-5.70)	(-5.95)	(-5.39)	(-6.14)
OPC	0.065***	0.064***	0.058***	0.067***	0.057***
	(4.62)	(4.54)	(4.18)	(4.77)	(4.13)
DSC	−0.040**	−0.039**	−0.047***	−0.039***	−0.045***
	(-2.51)	(-2.42)	(-2.98)	(-2.46)	(-2.82)
COS	0.089***	0.090***	0.078***	0.087***	0.075***
	(19.33)	(19.66)	(16.73)	(18.12)	(15.35)
Cons	−1.728***	−0.957***	−1.262***	−1.737***	−1.01***
	(-83.23)	(-8.48)	(-27.90)	(-78.99)	(-9.13)
Year	Yes	Yes	Yes	Yes	Yes
Region	Yes	Yes	Yes	Yes	Yes
Industry	Yes	Yes	Yes	Yes	Yes
Adj R^2	0.207	0.211	0.236	0.205	0.241

Note: *$p < 0.1$, **$p < 0.05$, ***$p < 0.01$, t statistics are in parentheses.

5.2.2. SCC

Columns (4) and (5) examine the mediating effect of **SCC** in Table 6. The coefficient of **DTA** in column (4) is significantly positive ($\varphi_1 = 0.041$; $p < 0.01$), indicating that the DTA improves the science and transparency of decision-making and promotes the efficiency of **SCC**. This result confirms the findings of (Nguyen et al., 2022). The **DTA** provides information management for upstream and downstream corporations in the **SC**, providing analytical support for decision-makers (Nguyen et al., 2022). The coefficients for both the **DTA** and **SCC** in column (6) are significantly positive ($\varphi_1 = 0.042$; $\varphi_2 = 0.235$; $p < 0.01$), and the *Sobel* test is significant ($p < 0.01$), suggesting that there is a partial mediating effect of **SCC**. **DTA** empowers upstream and downstream corporations in the **SC** to achieve seamless connectivity and information sharing, strengthening **SCC** and enhancing the supply chain's ability to absorb risks (Al-Omoush et al., 2023; Zhao et al., 2023). It demonstrates that **DTA** increases **SCC** and improves corporate **CEC**. H5b is verified.

5.2.3. SCI

Columns (6) and (7) report the results from the mediating effect test of **SCI** in Table 6. The **DTA** in column (6) negatively correlates with **CEC** ($\varphi_1 = -0.126$; $p < 0.01$). It contrasts with the results of Jajja et al. (2018) and Chen et al. (2023). The coefficient on the **DTA** in column (7) is significantly positive, and the coefficient on **SCI** is s negative, consistent with baseline results ($\varphi_1 = 0.046$; $\varphi_2 = -0.042$; $p < 0.01$). Simultaneously, the *Sobel* test passed the 5% significance test ($p < 0.05$). It signals that the **DTA** attenuates the adverse effects of **SCI** and strengthens **CEC**. In other words, **SCI** partially mediates between **DTA** and **CEC**. This finding is novel and interesting. H5c is verified. Additionally, we visualized the mediating effects of **SCRM**, **SCC,** and **SCI**, as illustrated in Fig. 2.

5.3. Further research

We measured corporate growth in terms of year-on-year growth in gross revenue and classified them into high- and low-growth subgroups based on whether it was above the median, with the results presented in Tables 7 and 8. The results in Table 7 indicate that the P values for the *Sobel* tests of mediating effects of **SCRM**, **SCC**, and **SCI** in low-growth firms are under the 5% significance level. Nevertheless, the results in high-growth firms are the opposite of those in low-growth firms. The *Sobel* test in Table 8 failed to satisfy the significance test. It suggests that the mediating effects of **SCRM**, **SCC**, and **SCI** are not substantiated. The empirical results prove that the mediating effects of **SCRM**, **SCC**, and **SCI** are more significant in low-growth firms, which verify H6a, H6b, and H6c.

5.4. Endogenous test

Endogenous issues are frequently encountered in empirical research and can misrepresent evidence results. Omitted variables and reciprocal causation are important causes of endogeneity. On the one hand, controlling for corporate financial characteristics, time trends, geographic locations, and industry categories in our study mitigate endogeneity partly. However, it does not eliminate the endogeneity disturbance caused by other unobserved variables. On the other hand, **DTA** by companies can contribute to their **CEC**. Meanwhile, companies with higher **CEC** are more equipped to apply digital technology. Thus, it

Table 6
Test results on the mediating effect.

Variable	Total effect	Mediating effect		Mediating effect		Mediating effect	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	CEC	SCRM	CEC	SCC	CEC	SCI	CEC
DTA	0.051***	0.004***	0.049***	0.041***	0.042***	−0.126***	0.046***
	(6.61)	(2.86)	(6.38)	(5.22)	(5.52)	(-7.86)	(5.90)
SCRM			0.485***				
			(5.08)				
SCC					0.235***		
					(14.10)		
SCI							−0.042***
							(-5.03)
ROA	−0.044	−0.009	−0.039	−0.052	−0.031	0.008	−0.043
	(-0.52)	(-0.63)	(-0.47)	(-0.63)	(-0.39)	(0.05)	(-0.52)
COA	−0.005***	0.001***	−0.005***	0.002**	−0.005***	−0.007***	−0.005***
	(-5.84)	(5.12)	(-6.28)	(2.06)	(-6.50)	(-4.56)	(-6.23)
OPC	0.119***	0.001	0.118***	0.064***	0.104***	−0.072**	0.116***
	(8.77)	(0.44)	(8.76)	(4.68)	(7.86)	(-2.57)	(8.57)
DSC	−0.034*	−0.004	−0.032*	0.036**	−0.042**	0.028	−0.033*
	(-1.88)	(-1.19)	(-1.78)	(1.98)	(-2.41)	(0.76)	(-1.82)
COS	0.070***	0.002**	0.069***	0.045***	0.059***	−0.084***	0.066***
	(16.13)	(2.14)	(15.99)	(10.42)	(13.85)	(-9.41)	(15.18)
Cons	−1.693***	−1.398***	−1.015***	−2.221***	−1.171***	−0.814***	−1.727***
	(-80.60)	(-371.25)	(-7.51)	(-105.40)	(-27.75)	(-18.81)	(-78.52)
Adj-R^2	0.112	0.015	0.119	0.057	0.161	0.066	0.118
Sobel_P		0.012		$1.000e^{-6}$		$2.279e^{-5}$	
Indirect effect		0.002		0.010		0.005	
Direct effect		0.049		0.041		0.046	
Total effect		0.051		0.051		0.051	

Note: *p < 0.1, **p < 0.05, ***p < 0.01, t statistics are in parentheses.

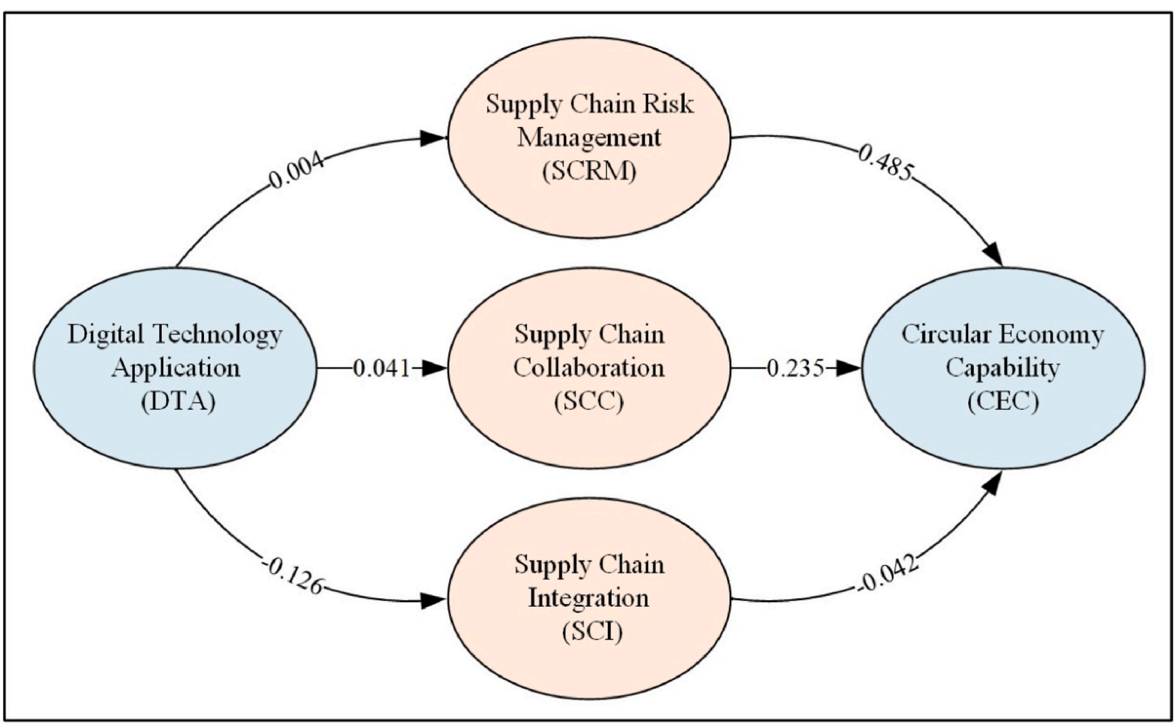

Fig. 2. Results on the mediating effect.

creates an endogenous issue of reciprocal causation. It is also the case with **SCM** and **CEC**.

To further alleviate the endogeneity, we employ an instrumental variables method. The lagged term of **DTA** and the average of **DTA** in other firms in the corporate industry were chosen as instrumental variables in the endogenous test of **DTA** affecting **CEC**. Correspondingly, the lagged term of **SCM** (i.e., the lagged terms of **SCRM**, **SCC**, and **SCI**) and the average of **SCM** (i.e., **SCRM**, **SCC**, and **SCI**) in other firms in the corporate industry were selected as instrumental variables in the endogenous test of **SCM** affecting **CEC**. The lagged terms of **DTA**, **SCRM**, **SCC**, and **SCI** are predicated on the research of Reed (2015) and Bellemare et al. (2017), who concluded that the lagged terms of the explanatory variables could be treated as instrumental variables. The averages of **DTA**, **SCRM**, **SCC**, and **SCI** are attributable to peer effect.

Table 7
Test results on the mediating effect in low-growth firms.

Variable	Total effect	Mediating effect		Mediating effect		Mediating effect	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	CEC	SCRM	CEC	SCC	CEC	SCI	CEC
DTA	0.044***	0.004**	0.042***	0.039***	0.035***	−0.100***	0.040***
	(4.75)	(2.42)	(4.56)	(4.16)	(3.82)	(-5.25)	(4.30)
SCRM			0.435***				
			(4.12)				
SCC					0.247***		
					(12.54)		
SCI							−0.041***
							(-4.13)
ROA	−0.108	−0.006	−0.106	−0.138	−0.074	0.041	−0.107
	(-1.08)	(-0.29)	(-1.06)	(-1.38)	(-0.77)	(0.20)	(-1.07)
COA	−0.005***	0.001***	−0.006***	0.002**	−0.006***	−0.007***	−0.006***
	(-5.62)	(4.91)	(-6.02)	(2.18)	(-6.35)	(-3.73)	(-5.93)
OPC	0.132***	0.007**	0.128***	0.063***	0.116***	−0.080**	0.128***
	(7.38)	(2.18)	(7.21)	(3.50)	(6.70)	(-2.19)	(7.21)
DSC	−0.035*	−0.004	−0.033	0.042**	−0.045**	0.024	−0.033
	(-1.61)	(-1.05)	(-1.52)	(1.96)	(-2.16)	(0.56)	(-1.56)
COS	0.069***	0.002*	0.069***	0.046***	0.058***	−0.064***	0.067***
	(13.48)	(1.66)	(13.37)	(8.92)	(11.44)	(-6.09)	(12.91)
Cons	−1.675***	−1.404***	−1.064***	−2.224***	−1.126***	−0.902***	−1.712***
	(-65.20)	(-283.67)	(-7.07)	(-86.30)	(-22.32)	(-17.18)	(-63.10)
Adj-R^2	0.105	0.020	0.111	0.054	0.159	0.044	0.111
Sobel_P		0.037		$7.775e^{-5}$		0.001	
Indirect effect		0.002		0.010		0.004	
Direct effect		0.042		0.034		0.040	
Total effect		0.044		0.044		0.044	

Note: *p < 0.1, **p < 0.05, ***p < 0.01, t statistics are in parentheses.

Table 8
Test results on the mediating effect in high-growth firms.

Variable	Total effect	Mediating effect		Mediating effect		Mediating effect	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	CEC	SCRM	CEC	SCC	CEC	SCI	CEC
DTA	0.056***	0.003	0.054***	0.032	0.050***	−0.187***	0.050***
	(3.03)	(1.11)	(2.94)	(1.60)	(2.77)	(-4.63)	(4.30)
SCRM			0.637**				
			(2.14)				
SCC					0.177***		
					(4.34)		
SCI							−0.028
							(-1.41)
ROA	0.192	−0.006	0.196	0.324	0.135	0.001	0.192
	(0.97)	(-0.23)	(1.00)	(1.57)	(0.69)	(0.01)	(0.97)
COA	−0.001	0.001	−0.001	0.002	−0.001	−0.007*	−0.001
	(-0.34)	(1.37)	(-0.46)	(0.85)	(-0.50)	(-1.68)	(-0.44)
OPC	0.078***	−0.009**	0.084***	0.091**	0.062**	−0.078	0.076***
	(3.03)	(-2.38)	(3.24)	(3.40)	(2.42)	(-1.38)	(2.95)
DSC	−0.021	−0.005	−0.018	−0.009	−0.019	−0.010	−0.021
	(-0.46)	(-0.72)	(-0.40)	(-0.19)	(-0.44)	(-0.10)	(-0.47)
COS	0.070***	0.003**	0.068***	0.043***	0.063***	−0.135***	0.066***
	(6.84)	(2.11)	(6.64)	(3.99)	(6.11)	(-6.00)	(6.27)
Cons	−1.749***	−1.392***	−0.861**	−2.253***	−1.350***	−0.585***	−1.765***
	(-36.79)	(-202.70)	(-2.06)	(-45.42)	(-13.10)	(-5.61)	(-36.12)
Adj-R^2	0.130	0.015	0.136	0.078	0.158	0.138	0.132
Sobel_P		0.326		0.122		0.176	
Indirect effect		0.002		0.006		0.005	
Direct effect		0.054		0.050		0.051	
Total effect		0.056		0.056		0.056	

Note: *p < 0.1, **p < 0.05, ***p < 0.01, t statistics are in parentheses.

Firms within the identical industry may cooperate or compete, prompting frequent and intensely interactive **DTA** and **SCM** between various firms, which provokes imitative practices among firms. **DTA** and **SCM** of firms in the identical industry may have an impact on the **DTA** and **SCM** of the individual but does not directly affect its **CEC**. These results, as reported in Table 9, indicate that *Anderson Canon. Corr. LM Statistic* and *Cragg-Donald Wald F Statistic* passed the significance test. Instead, the P-values of the *Sargan Statistic* are greater than 5% significance. The results suggested that instrumental variables align with the correlation and exogeneity requirements. Results from Table 9 reveal that the effect of **DTA**, **SCRM**, and **SCC** on **CEC** continued to be positive ($\alpha_1 = 0.055$; $\beta_1 = 0.518$; $\chi_1 = 0.220$; $p < 0.01$), while that of **SCI** on **CEC** was also negative ($\delta_1 = -0.059$; $p < 0.01$). They align with baseline results, suggesting that endogeneity does not confound our

Table 9
Endogenous test results.

Variable	(1)	(2)	(3)	(4)
	CEC	CEC	CEC	CEC
DTA	0.055*** (3.56)			
SCRM		0.518*** (5.03)		
SCC			0.220*** (9.46)	
SCI				−0.059*** (-3.26)
ROA	−0.042 (-0.47)	−0.007 (-0.08)	−0.024 (-0.29)	−0.009 (-0.10)
COA	−0.004*** (-4.71)	−0.005*** (-5.31)	−0.005*** (-5.56)	−0.005*** (-5.22)
OPC	0.049*** (3.35)	0.049*** (3.36)	0.044*** (3.06)	0.053*** (3.64)
DSC	−0.042** (-2.20)	−0.039*** (-2.09)	−0.048** (-2.58)	−0.039** (-2.06)
COS	0.085*** (16.97)	0.087*** (17.62)	0.075*** (14.79)	0.081*** (14.94)
Anderson canon. corr. LM statistic	829.308***	2722.730***	1680.017***	1134.106***
Cragg-Donald Wald F statistic	569.561***	$2.100e^{4}$***	1951.851***	912.576***
Sargan statistic P-value	0.483	0.735	0.065	0.261
R^2	0.117	0.124	0.151	0.114

Note: *p < 0.1, **p < 0.05, ***p < 0.01, t statistics are in parentheses.

findings.

5.5. Robustness test

We demonstrate the robustness of the results by changing the method and period. First, we re-examine the existence of the mediating channel of **SCRM**, **SCC**, and **SCI** between **DTA** and **CEC** using the two-stage least squares (**2SLS**) approach. In the first stage, we investigate the impact of **DTA** on **SCRM**, **SCC**, and **SCI**. In the second stage, we examine the impact of **SCRM**, **SCC**, and **SCI** on **CEC**. Table 10 reports the robustness test results and shows that in the first stage, **DTA** positively affects **SCRM** and **SCC**, but **it** hurts **SCI**. In the second stage, **SCRM** and **SCC** are positive for **CEC**, and **SCI** harms **CEC**. These results indicate that **SCRM**, **SCC**, and **SCI** are mediating channels between **DTA** and **CEC**.

Second, the COVID-19 epidemic, as an unexpected event, negatively impacted corporate operations. Its occurrence may interfere with our findings. Hence, we have adjusted the research period from 2015 to 2019 for robustness testing, as shown in Table 11. Table 11 displays that the P values for the **SCRM**, **SCC**, and **SCI** mediating effects tests satisfy the significance requirement, demonstrating that the mediating effects hold. It reflects the fact that the COVID-19 epidemic did not produce a shock to the findings.

6. Conclusions and implications

6.1. Conclusion

From a dynamic capability view, we investigated the impact of **DTA**, **SCRM**, **SCC**, and **SCI** on **CEC** and surveyed the mediating effects of SCRM, SCC, and SCI in the relationship between **DTA** and **CEC**. We have been supported by empirical evidence that the **DTA**, **SCRM**, and **SCC** positively affect **CEC**. **SCI** negatively affects **CEC**. Then, we examined **SCRM**, **SCC**, and **SCI** as mediating channels between **DTA** and **CEC**. The **DTA** facilitates **SCRM** and **SCC**, improving **CEC**. The difference is that the **DTA** enhances **CEC** by inhibiting **SCI**. In addition, we further tested the above relationship across various growth firms. We found that the mediating channels of **SCRM**, **SCC**, and **SCI** in **DTA** affecting **CEC** are more significant in low-growth corporations. According to these findings, we may conclude that **DTA** enables enterprises to develop their **CEC** not only by gaining advantages from individual enterprises applying digital technology but also from dynamics between different individual enterprises in the **SC** through digital technology.

6.2. Theoretical implications

Our study draws specific theoretical implications for explaining the connection between **DTA**, **SCM**, and **CEC** and also contributes to filling existing research gaps.

First, we explore a key issue regarding the material impact of digital technology applications on circular economy capabilities to enrich the

Table 10
Robustness test results: Replacement method.

Variable	(1)	(2)	(3)	(4)	(5)	(6)
	CEC	SCRM	CEC	SCR	CEC	SCR
DTA		0.005*** (3.51)		0.035*** (4.47)		−0.026** (-1.95)
SCRM	6.523*** (2.84)					
SCC			0.928*** (3.43)			
SCI					−1.254* (-1.79)	
ROA	−0.010 (-0.08)	−0.010 (-0.67)	−0.073 (-0.73)	−0.002 (-0.03)	−0.047 (-0.24)	0.023 (0.16)
COA	−0.009*** (-4.38)	0.001*** (4.97)	−0.007*** (-5.47)	0.002*** (2.96)	−0.011*** (-2.64)	−0.005*** (-3.71)
OPC	0.037* (1.63)	0.004 (1.69)	0.027 (1.31)	0.041*** (2.96)	0.101*** (2.69)	0.029 (1.21)
DSC	−0.021 (-0.79)	−0.003 (-0.92)	−0.072*** (-3.10)	0.034** (1.95)	0.019 (0.36)	0.047 (1.57)
COS	0.082 (11.08)	0.001 (1.20)	0.036** (2.09)	0.057*** (12.23)	−0.062 (-0.72)	−0.120*** (-15.00)
Cons	7.020** (2.17)	−1.409*** (-59.86)	0.340 (0.46)	−2.705*** (-20.81)	−4.431*** (-3.38)	−1.802*** (-8.13)
Year	Yes	Yes	Yes	Yes	Yes	Yes
Region	Yes	Yes	Yes	Yes	Yes	Yes
Industry	Yes	Yes	Yes	Yes	Yes	Yes

Note: *p < 0.1, **p < 0.05, ***p < 0.01, t statistics are in parentheses.

Table 11
Robustness test results: Replacement period.

Variable	Total effect	Mediating effect		Mediating effect		Mediating effect	
	(1)	(2)	(3)	(5)	(6)	(8)	(9)
	CEC	SCRM	CEC	SCC	CEC	SCI	CEC
DTA	0.062***	0.006***	0.059***	0.042***	0.051***	−0.051***	0.060***
	(6.44)	(3.32)	(4.36)	(4.44)	(5.46)	(-2.80)	(6.22)
SCRM			0.495***				
			(4.36)				
SCC					0.259***		
					(13.16)		
SCI							−0.044***
							(-4.14)
ROA	−0.102	−0.003	−0.101	−0.082	−0.081	−0.022	−0.103
	(-0.98)	(-0.16)	(-0.97)	(-0.79)	(-0.80)	(-0.11)	(-0.99)
COA	−0.006***	0.001***	−0.006***	0.002**	−0.006***	0.001	−0.006***
	(-5.99)	(4.67)	(-6.39)	(2.06)	(-6.74)	(0.23)	(-5.99)
OPC	0.149***	0.003	0.147***	0.076***	0.129***	−0.083**	0.145***
	(8.84)	(1.11)	(8.77)	(4.56)	(7.90)	(-2.58)	(8.64)
DSC	−0.044**	−0.004	−0.042**	0.037*	−0.053***	0.033	−0.042**
	(-2.14)	(-1.07)	(-2.05)	(1.81)	(-2.69)	(0.85)	(-2.07)
COS	0.075***	0.001	0.074***	0.046***	0.063***	−0.093***	0.071***
	(14.60)	(1.54)	(14.51)	(9.05)	(12.48)	(-9.52)	(13.59)
Cons	−1.723***	−1.400***	−1.029***	−2.231***	−1.144***	−0.789***	−1.757***
	(-68.94)	(-314.69)	(-6.38)	(-89.56)	(-22.83)	(-16.51)	(-66.89)
Adj-R^2	0.131	0.018	0.137	0.059	0.189	0.047	0.137
Sobel_P		0.008		$2.624e^{-5}$		0.020	
Indirect effect		0.003		0.011		0.002	
Direct effect		0.059		0.051		0.060	
Total effect		0.062		0.062		0.062	

Note: *p < 0.1, **p < 0.05, ***p < 0.01, t statistics are in parentheses.

literature on digital technology and the circular economy. Nowadays, **DTA** and **CEC** are necessary for enterprises to acquire competitive advantages and achieve sustainable development, respectively. Nevertheless, their relationship is unclear in the existing literature. We bridge the gap on this issue by examining the relationship between **DTA** and **CEC**.

Second, our research analyses the theoretical implications of **SCM** (i.e., **SCRM**, **SCC,** and **SCI**) on **CEC** from a **DC** perspective, establishing a connection between **SCDC** and corporate **DC**. Previous research has emphasized the importance of corporate **DC** and has extensively explored its influencing factors or economic consequences. Nevertheless, these research perspectives have neglected the enhancement of **DC** from **SCDC**. The **DC** view is a new perspective that explores the relationship between corporate **SCDC** and **DC**. Under the **DC** view, we analyze the facilitating effects of **SCRM** and **SCC** on **CEC** based on prior studies and discuss the inhibiting impact of **SCI** on **CEC**, which differs from earlier studies.

Third, our research analyses that **SCRM** (i.e., **SCRM**, **SCC,** and **SCI**) exhibits a mediating effect in the impact of **DTA** and **CEC**, which is our core contribution and an area that has not received sufficient focus in existing research. Fig. 1 offers a conceptual framework to support the importance of **DTA** to enhance **CEC** through improving **SCRM** for empirical evidence. **DTA** enhances **CEC** from management model, organizational structure, and product services and also assists enterprises in acquiring **CEC** from **SCRM**. Our research provides theoretical justification for clarifying the mediating channels through which **DTA** affect **CEC** and for developing viable pathways for enterprises to enhance their **CEC.**

6.3. Practical implications

Our findings have implications for how companies can effectively utilize DTA to enhance CEC by SCM. **First,** firms should pay attention to the significant change effect of digital technology. Enterprises, combined with practical, are required to accelerate to apply the digital technology in the production, operation, and management process, making optimal utilization of digital technology in allocating resources, reducing costs, and improving human capital level, thereby effectively enhancing **CEC**. **Second,** we found that **DTA** facilitates **SCRM** and **SCC**, thereby improving **CEC**, making it necessary for corporations to emphasize **SCRM** and **SCC** when developing **SCDC**. **SCRM** and **SCC** can bring new impetus to **CEC**. Companies must also embrace **SCRM** and **SCC** as essential strategies for integrating **SC** resources and driving **CEC**. Companies should be geared towards end-user demand, leverage digital technology, appeal to **SC** groups to strengthen **SCRM**, encourage joint decision-making by **SC** groups, and share knowledge or technology about **CE** in product iterations and operational process improvements. Simultaneously, **DTA** can mitigate the negative impact of corporate **SCI** on **CEC**, which reflects that excessive attention to **SCI** may not be a good practice. **Third**, firms should select their **DTA** and **SCM** in conjunction with their level of growth. High-growth firms are inherently uncertain and have few financial resources. The blind application of **DTA** and over-strengthening **SCM** may be counterproductive. Consequently, applying digital technology and strengthening **SCM** by high-growth companies requires a step-by-step strategy.

Our research provides implications for government policy formulation. **First,** the government should emphasize the role of **DTA** in promoting **CEC** and guide enterprises to accelerate the pace of **DTA**. They can increase their support for enterprises to apply digital technology, accelerate the formulation of reasonable support policies, and effectively solve the significant problems of weak application or high costs while focusing on promoting the construction of commercial digital technology infrastructure and improving the accessibility of digital infrastructure for enterprises. **Second,** forming the nexus between **DTA, SCM,** and **CEC** also requires adequate government safeguards. Policy incentives should encourage enterprises to engage in **DTA, SCM,** and **CEC.** Simultaneously, the subsidy audit system should be sounded to avoid the strategic behavior of enterprises for arbitrage. **Third,** when formulating support policy, the government should fully consider corporate growth, decrease *one-size-fits-all* general guidelines and increase guidance and support for high-growth enterprises.

6.4. Limitations and future research

Some limitations can further research. First, we only select A-share listed industrial corporations as the research sample from a research perspective, and the service industry is not included in the research scope. Additionally, although this paper considers corporate growth, other characteristics, such as ownership attributes, have not been incorporated. The impact of **DTA** on **CEC** and the mediating channels of **SCRM**, **SCC**, and **SCI** between **DTA** and **CEC** may vary across industries or ownership attributes. Consequently, further research is needed to expand the research scope. Second, some research has been conducted to test for a non-linear mediating effect by drawing on the moderating path analysis of Edwards and Lambert (2007). Follow-up studies can be conducted to further test the mediating effects of **SCRM**, **SCC**, and **SCI** between **DTA** and **CEC** in depth by using this methodology.

Credit author statement

Sai Yuan: Conceptualization, Methodology, Data curation, Writing, Original draft preparation. Xiongfeng Pan: Visualization, Investigation, Supervision, Software, Validation.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

Data will be made available on request.

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