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The influence of digital transformation on the supply chain finance level

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In the new era, supply chain finance (SCF), as an emerging financial model, has gradually become an important means for enterprises to develop and improve supply chain efficiency. The continuous development and application of digital technology have brought unprecedented opportunities and challenges for the digital transformation of SCF. This article is based on the data of non-financial industry listed companies in China's Shanghai and Shenzhen A-shares from 2007 to 2021. It examines the relationship between digital transformation and enterprise SCF. Research has found that the degree of digital transformation and SCF level of enterprises are constantly increasing. The digital transformation of enterprises is conducive to improving their SCF levels and to further exploring the impact of various dimensions of digital transformation on SCF levels. This promoting effect still exists. This study aims to provide a profound and practical theoretical basis for digitizing the SCF level, thereby highlighting the importance and value of SCF in the modern economy.

KEYWORDS

digital transformation, level of supply chain finance, financial model, correlation analysis, multiple collinearity test

1 Introduction

With intensified global competition, the development of emerging technologies such as cloud computing, Internet of Things, big data analysis, and artificial intelligence, the increasingly diversified and personalized modern consumer needs, and the increasing pursuit of high-quality and responsive services have brought revolutionary changes to supply chain management. The COVID-19 pandemic exposed critical vulnerabilities in traditional supply chains, such as fragmented information flows, delayed physical inspections, and disrupted payment settlements, forcing enterprises to accelerate digital transformation [1]. Supply chain finance (SCF) is a comprehensive financial service mode based on the supply chain system and financial means. As a new financial model, through the flow of funds and risk management, it can establish the channel of capital flow, speed the cash flow to improve the credibility of the supply chain, and solve the different links in the supply chain enterprise funding gap problem. Gelsomino et al. [2] believe that the SCF definition reflects two main views, namely, the "financial-oriented" view and the "supply chain-oriented" view. Xu et al. [3] mentioned that it not only provides financial support and risk reduction services for enterprises in the supply chain but has also become an important means for enterprises to realize their own development and improve supply chain

efficiency. SCF plays an important role in improving the operational efficiency of supply chain operations, promoting capital flow, and reducing risks. In the context of the era of digital intelligence, with the continuous development and application of digital technology, SCF will usher in a broader space for development, create more opportunities and innovative applications, and bring unprecedented opportunities and challenges for its improvement. In the framework research of SCF platforms, Jia et al. [4] built a comprehensive conceptual framework of SCF based on the perspective of information processing to illustrate how suppliers cope with uncertainty, develop capabilities, and further realize the integration of the entire financial supply chain. Chen et al. [5] used the SMAA-2 model to comprehensively evaluate various SCF platforms. Caniato et al. [6] built an SCF framework based on the history of SCF, the current research, and the future development perspective. In the study of the SCF relationship, Wetzel and Hofmann [7] analyzed the SCF constraints in the focus company's performance maximization of working capital level and put forward the relationship between working capital and enterprise performance. Beka et al. [8] discussed four factors that affect the application of SCF in the effectiveness of the supply chain.

Recent research highlights the broader role of digital transformation in supply chain resilience and regulatory compliance. Gkoni et al. [9] examine how EU customs digitalization, driven by eCommerce VAT legislation, improves cross-border supply chain efficiency, emphasizing that digital systems reduce administrative delays and enhance financial transparency, which are critical for cross-border SCF. Durmanov et al. [10] develop an economic model for greenhouse facility management, showing that digitalization optimizes resource allocation and cash flow management, providing a micro-level example of how digital tools support SCF by stabilizing operational cash flows. Attah et al. [11] propose a strategic framework for executives, arguing that AI enhances supply chain resilience by enabling real-time risk monitoring, which in turn reduces default risks and improves SCF accessibility. These studies complement our research by linking digital transformation to regulatory adaptation, operational stability, and resilience, which are key enablers of effective SCF.

Among them, digital transformation factors such as information sharing and digitalization were discussed and can provide a reference for the research of this article. Therefore, based on the data of listed companies in Shanghai and Shenzhen A-share non-financial industry from 2007 to 2021, this article deeply examines the digital transformation and its relationship with various dimensions and SCF to realize the importance and value of SCF in the modern economy.

2 Theoretical analysis and the mechanism of action

2.1 The mechanism of digital transformation on the SCF level

Digital transformation is embodied in technological progress, where rapid progress makes data collection, processing, and analysis more efficient, making optimization of the supply chain and intelligent decision-making possible. For example, manufacturing firms in China adopted blockchain-based traceability systems to ensure transparency in raw material sourcing amid lockdowns, while European logistics companies leveraged AI-driven demand forecasting to mitigate shipment delays caused by border closures [12]. First, in the procurement link of the supply chain, artificial intelligence can monitor the order quantity, supplier credit, and other indicators in real time, and suppliers can understand the inventory situation and order demand in real time through the system and adjust the production and supply plan in time to realize the efficient coordination of the supply chain. At the same time, suppliers can find bottlenecks and irrationality in the process, inform the relevant parties to adjust and respond, and propose an optimization plan [13]. Second, in the business link of the supply chain, the system can automatically recommend the most suitable supply chain financing method and amount according to the supply chain situation and historical transaction data of the enterprise or intelligently match and recommend suitable supply chain financial products according to the needs of the enterprise, to improve the personalization and accuracy of financial products. The third is in the payment link of the supply chain. In traditional SCF, the payment process usually requires multifaceted participation and complex confirmation operations, which are prone to delays and errors. After the digital transformation, the digital payment system can seamlessly dock with the enterprise's internal financial and supply chain management system, realize the entire automatic payment process, and capital transfer and distribution can be achieved in real-time and automatically. Payment efficiency and accuracy are improved, further reducing the risk of human errors and allowing management to make more scientific and accurate financial decisions. In the process of digital transformation on the SCF level, the main products of SCF play an important role in improving the level of SCF. It aims to meet the financing needs of all links in the supply chain, including accounts receivable financing, inventory financing, and order financing, providing more flexible and personalized financial services. These products meet the financial needs of all aspects of the supply chain by providing financing support, risk management, collection services, and optimizing settlement and taxation. In the application process, supply chain enterprises should choose according to their own needs and give full play to the benefits of these products to realize the digital upgrading of SCF. Among them, the digital transformation simplifies and accelerates the capital settlement process between enterprises, providing a more efficient and transparent settlement method and reducing the transaction costs in the supply chain. In addition, the digital transformation breaks through the original information barrier and can simplify tax planning in the supply chain, reduce tax risks and costs, and improve the operating efficiency of enterprises [14].

2.2 The mechanism of enabling SCF in each dimension of digital transformation

First, the dimension of artificial intelligence. Artificial intelligence is gradually infiltrating every link of SCF, providing more efficient and accurate services for SCF. The use of artificial intelligence makes SCF more automated, which can be reflected in the automation of the payment process, risk control, and credit

evaluation, which improves efficiency and accuracy by reducing manual intervention and also reduces operational risk. At the same time, AI can analyze the supply chain data, better understand the operation of the supply chain, provide decision support, optimize capital flow and capital allocation, and improve the utilization rate of funds [15]. AI is applied in the automated contract management and execution process. In traditional SCF, contract management and execution usually require manual participation and complex processes, which are prone to disputes and delays. However, after the introduction of an automated contract management system, automatic creation, signing, execution, and archiving of contract management can be completed by the artificial intelligence system, which not only reduces the time and energy cost of contract management but also improves the efficiency and accuracy of contract execution [16]. Therefore, supply chain enterprises should actively apply artificial intelligence at the financial business level to improve their digital level.

Second, the big data dimension. In the current digital era, the development of SCF has completely changed the operation mode of traditional SCF. Big data has become one of the important methods of realizing the digital improvement of SCF, mainly focusing on the construction of the information system and the optimization of information flow. The construction of an efficient, large data information system is the core of supply chain financial informatization, supporting information sharing and data exchange, real-time communication and collaboration between SCF participants, and achieving resource integration and complementary advantages to improve the efficiency and transparency of SCF [17]. The application of big data can realize the rapid transmission and accurate input of SCF business data, reduce the use of manual operation and paper documents, improve the speed and accuracy of data transmission, and reduce the cost and error rate of information transmission. In addition, the digital system sharing platform based on big data enables all parties in the supply chain to share data, information, and resources, realize effective resource allocation, and develop customized SCF solutions more in line with the needs, so as to promote intelligent management [18].

Third, the cloud computing dimension. In the era of digital intelligence, the rapid development of cloud computing technology has provided new opportunities to improve SCF, which has many advantages and benefits. First, the cloud computing platform uses the Internet to access and interact, places the SCF business, data storage, processing, and other functions in the cloud, improves the data analysis and decision-making ability, and makes the data and business processing of SCF more convenient and efficient. Second, the cloud computing platform builds an open financial ecological environment, realizes the sharing and integration of resources and capabilities, provides real-time and cross-regional data sharing and interaction, promotes cooperation and coordination among all participants, and helps SCF to realize intelligent management and service. Similarly, geopolitical tensions (e.g., trade restrictions between major economies) have highlighted the need for cloud-based supply chain finance platforms that enable cross-regional real-time collaboration and risk monitoring [19]. As can be seen from the above, the cloud computing application of SCF will usher in a broader development space and a higher level. SCF platforms should actively embrace cloud computing technology, accelerate the process of cloud computing, and constantly improve their competitiveness and service level.

Fourth, the blockchain dimension. The establishment of a blockchain-based SCF platform can realize the transparency and traceability of credit information and transaction information in the supply chain and improve the security and credibility of financial transactions. The blockchain connecting SCF realizes the information sharing and efficient flow of resources, improves the efficiency of information transmission and communication, reduces the risk of information asymmetry, and provides strong support for the development of SCF, to promote the refinement of SCF management and scientific decision-making [20]. Blockchain uses encryption technology to ensure the security and privacy of data stored on the network, which helps protect sensitive information such as trade secrets, financial data, and customer information from unauthorized access and cyberattacks. In addition, blockchain technology also expands financing channels and business boundaries through the establishment of a network platform that can attract more financial institutions to participate in SCF, provide a wider range of financial services for supply chain participants, and expand financing sources and channels [21].

Fifth, the digital technology dimension. Digital technology provides an efficient and convenient trading platform for SCF. Traditional SCF has problems of information asymmetry and high transaction costs. Through digital technology, information sharing and real-time transactions in all links of the supply chain can be realized, promoting the cooperation and coordination among all parties, reducing the transaction cost [22], and improving the efficiency of SCF. The application of digital technology can also increase the risk management ability of SCF. The frequent occurrence of uncontrollable factors increases supply chain risks continuously. SCF involves many participants and complex transaction relationships, and risk control has always been an important factor restricting the development of SCF. Digital technology can realize the data collection, analysis, and mining of the whole process of the supply chain. Through the establishment of a risk early warning model and a dynamic monitoring system, it can find and respond to potential risks in time to realize the effective management and prevention of SCF risks. At the same time, digital technology can also promote the innovation and upgrading of SCF. Through the application of digital technology, the innovation of SCF products and services can be realized, the service scope and depth of SCF can be expanded, more diversified financing products and services can be provided, and the SCF model can be upgraded and optimized [23].

3 Study design

3.1 Variable selection

3.1.1 Explained variable: supply chain finance

Among the participants in SCF, the listed companies are often the core enterprises or leading enterprises that will act as guarantors and debtors, but they are not highly related to the developed SCF. In the supply chain, enterprises often must use bills or sales contracts to raise funds, which is the key to SCF. Therefore, examining the loan type of enterprises can effectively measure the development

level of SCF. Because there is still no specific index to measure the development level of SCF, this article draws on the research method of Xu et al. [3] and obtains the measurement of SCF. The expression is as follows: SCF = (short-term borrowing in the year + notes payable in the year)/the total assets of the company at the end of the year [24–26].

3.1.2 Explanatory variable: digital transformation

This article first summarizes the word frequency related to digital transformation and then summarizes the obtained word frequency. In order to further empirically test, logarithmic processing is done after the word frequency summary, as the alternative variable of the degree of digital transformation [27]. The detailed construction steps are shown below:

1. Step 1 Text source: extract the "Management Discussion and Analysis (MD&A)" section from annual reports using Python's PyPDF2, excluding samples with PDF formatting errors (98.7% retention).
2. Step 2 Keyword dictionary: develop a dictionary of 56 core digital transformation terms (e.g., "digital," "AI," and "big data") and 128 synonyms (e.g., "IoT" for "Internet of Things"), referencing the National Bureau of Statistics' digital economy glossary and Ji et al. [28].
3. Step 3 Word frequency processing: segment text with Jieba (custom financial dictionary) and remove stop-words (Harbin Institute of Technology stop-word list + context-specific terms like "company"). Normalize: NormFreq = keyword frequency/total MD&A word count. Log-transform: Dig = ln (1 + NormFreq) (avoids zero-value bias).
4. Step 4 Validation: randomly select 100 firms for dual-coder keyword counting (Kappa = 0.89, high consistency).

3.1.3 Control variables

Drawing on studies conducted by previous scholars, the control variables in this article include ① enterprise size (Lnasset), in terms of the natural logarithm of the total assets of the enterprise; ② asset-to-liability ratio (Lev), by the ratio of the total liabilities to the total assets; ③ profitability (Roa), repressed by the enterprise's return on equity; ④ enterprise productivity (Tfp), calculated by the linear programming (LP) method; ⑤ equity concentration degree (Top1), with the proportion of the largest shareholder shareholding expressed; ⑥ corporate governance structure (Dual), separation or integration of chairman and general manager; ⑦ industry competition level, the Huffendal index (Hhi), calculated on main business revenue. The calculation formula is: $Hhi_j = \sum_{i=1}^{n}\left(sale_{ij}/\sum_{i=1}^{n} sale_{ij}\right)^2$. All the variables and their definitions are shown in Table 1.

3.2 Model construction

The following model is verified for the impact of the degree of digital transformation on the SCF level of enterprises. The specific model is as follows:

$$\mathrm{Scf}_{i,t} = \beta_0 + \beta_1 Dig_{i,t} + \sum \gamma_j Controls_{j,i,t} + \mu_i + \delta_t + \varepsilon_{i,t} + \theta_{pro,t},$$

where i represents the individual, t indicates the year, $Controls_{j,i,t}$ represents the control variable, $\varepsilon_{i,t}$ indicates the random perturbation term, and $\theta_{pro,t}$ indicates the province-year fixed effect.

3.3 Data sources

This article takes 2007–2021 as the research range and takes all the Shanghai and Shenzhen A-share non-financial listed companies as the research object. The data mainly come from the Guotai'an database, the CNRDS database, and the annual reports of listed companies. In order to ensure the reliability of the results, the missing observations of the data were excluded, and the tail was reduced by 1%, resulting in 34,072 observations of 4208 enterprises from 2007 to 2021.

4 Analysis of the empirical results

4.1 Descriptive statistics

Descriptive statistics of the variables involved are shown in Table 2. The mean value of SCF (Scf) is 0.140, indicating that the overall level of SCF of enterprises is not high. Scf ranges from 0 to 0.576, indicating significant variation in SCF adoption. The mean value of digital transformation (Dig) is 1.191. Dig ranges from 0 (no digital transformation mentions) to 6.301, reflecting uneven digital progress across firms. The polarization is relatively obvious, indicating that the degree of digital transformation of enterprises still has much room for improvement. The coefficient of Dig (0.0017, $p < 0.01$) in the baseline regression indicates that, controlling for other variables, a 1-standard-deviation increase in Dig (1.368, Table 2) raises the SCF by 0.0017×1.368 ˜ 0.0023, equivalent to 1.64% of the SCF mean (0.140). For a typical sample firm with 1 billion RMB in total assets, this translates to a ~2.3 million RMB increase in the SCF scale, effectively alleviating the funding gaps of small and medium-sized enterprises (SMEs). The statistics of all the variables are shown in Table 2.

4.2 Characteristic facts of digital transformation and SCF level

The enterprise attaches great importance to the degree of digital transformation. The digital degree has been on a rising trend, from 0.1636 in 2007 to 1.7806 in 2021, increasing 10 times. This also illustrates the continuous development and application of digital technology so that the enterprise has gradually realized the digital transformation in its management and operation. Meanwhile, the SCF level has been gradually improving. However, the speed of improvement has been relatively slow, from 0.0925 in 2007 to 0.1988 in 2021, which shows that enterprises continuously strengthen in the "capital" between "production" mutual collaboration, effectively alleviating the "financing" and "management" problem and solving the lack of funds. Figure 1 shows the relative increases of digital transformation and SCF level over the period examined in this article.

TABLE 1 Variable definition table.

Classify	Variable	Symbol	Definition
Explained variable	Supply chain finance	*Scf*	(Short-term loan of the current year + notes payable for the current year)/total assets of the company at the end of the current year
Explanatory variable	Digital transformation	*Dig*	Summarize the word frequency and take the logarithm
Control variable	Scale	*Lnasset*	The natural logarithm of the total corporate assets
	Asset-to-liability ratio	*Lev*	The ratio of total enterprise liabilities to total assets
	Profitability	*Roa*	Corporate return on equity
	Enterprise productivity	*Tfp*	Calculated using the LP method
	Equity concentration	*Top1*	The proportion of the largest shareholders
	Enterprise governance structure	*Dual*	Chairman and general manager are separated or integrated
	Industry competition	*Hhi*	$Hhi_j = \sum_{i=1}^{n}\left(sale_{ij}/\sum_{i=1}^{n} sale_{ij}\right)^2$, main business revenue

TABLE 2 Descriptive statistics.

Variable	Observed value	Mean	Median	Standard deviation	Min	Max
Scf	34,072	0.140	0.114	0.132	0	0.576
Dig	34,072	1.191	0.693	1.368	0	6.301
Lnasset	34,072	21.990	21.820	1.333	10.840	28.640
Lev	34,072	0.420	0.410	0.210	0.050	0.953
Roa	34,072	0.040	0.040	0.067	−0.285	0.213
Top1	34,072	0.349	0.327	0.152	0.003	1
Dual	34,072	0.283	0	0.447	0	1
Tfp	34,072	7.794	7.699	0.992	5.544	10.660
Hhi	34,072	0.136	0.087	0.146	0.014	1

4.3 Multiple collinearity test

This section performs multiple collinearity tests for each variable, and the test results are shown in Table 3. A VIF value within 3 indicates that there is no serious collinearity and does not cause significant interference to the regression results. The test results show that there is no significant multicollinearity among the variables but cannot testify to the absence of endogeneity (e.g., reverse causality between digital transformation and SCF).

4.4 Correlation analysis

In this section, the measurement software Stata is used to conduct the correlation analysis of each variable and determine whether there is a correlation between the selected variables using the Pearson correlation coefficient. Table 4 shows the results of the variable correlation coefficient. According to the results of the correlation analysis, there is a correlation between the variables.

4.5 Benchmark regression analysis

The Hausman test was used for the benchmark regression analysis. The null hypothesis was rejected because the Hausman test was significant, and a fixed-effect model was used. The benchmark regression results of the degree of digital transformation on the level of enterprise SCF are shown in Table 5. According to column (1) in Table 5, the regression coefficient of digital transformation (Dig) is 0.0016 at the 1% level, which preliminarily proves that

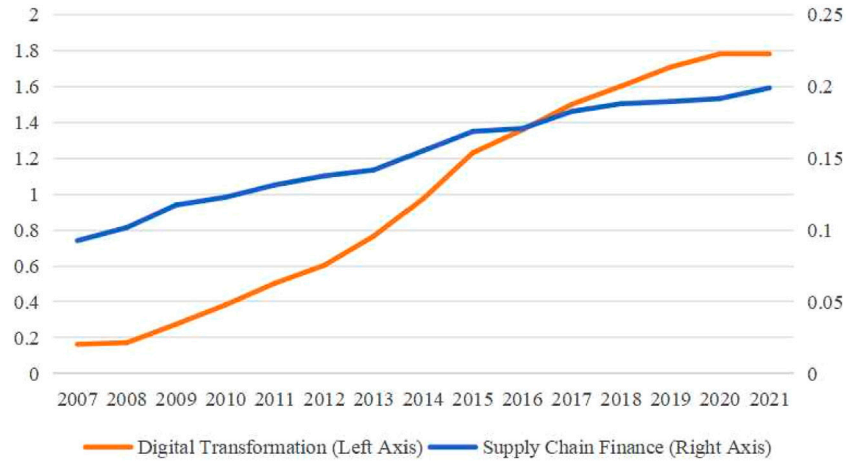

FIGURE 1
Time trends in digitalization and SCF (2007–2021).

TABLE 3 Multiple collinearity test.

Variable	VIF	1/VIF
Dig	2.69	0.371303
Lnasset	2.5	0.400136
Lev	1.51	0.661032
Roa	1.3	0.769312
Top1	1.11	0.904513
Dual	1.09	0.917909
Tfp	1.05	0.956005
Hhi	1.01	0.990259
Mean	1.52	

digital transformation can promote enterprise SCF. The control variables in columns (2) to (8) in Table 5, according to column (2), when joining the scale of the enterprise, the coefficient of digital transformation and enterprise SCF is 0.0005 and is not significant. The regression coefficient of enterprise size is significantly negative at the level of 1%, which means that the larger the enterprise is, the greater the negative impact on the level of enterprise SCF, probably because of the large size of the enterprise. Any operational risks or financial problems encountered will have an impact on the entire supply chain. Financial institutions will be more cautious when considering providing financing support. This can damage financial levels across the supply chain; thus, the positive relationship between the degree of digital transformation and the level of enterprise SCF is not significant. Tables 3–6 show that when other control variables are added, the relationship between the degree of digital transformation and the level of enterprise SCF is significantly positive. They indicate that the degree of digital transformation improves the level of the enterprise supply chain.

4.6 Point dimensional regression analysis

In the process of digital enterprise transformation, enterprises will focus on "digital technology driven" to transform and improve the digitalization degree of the original technology system and production system, which depends on the layout and development of key core technologies. Therefore, the impact of artificial intelligence, big data, and cloud computing on the level of enterprise SCF is further analyzed from the five dimensions of cloud intelligence, blockchain, and digital technology. All these are reflected in Table 6.

At the 1% level, Table 6 columns (1)–(2) show that in terms of artificial intelligence, big data, and SCF, the level coefficient is significant. Usually, artificial intelligence and big data technology enable enterprises to quickly process and analyze large supply chain data, help enterprises to more accurately predict demand, optimize inventory management, improve on-time delivery, reduce operating costs, and improve the level of gold enterprise SCF.

Table 6 columns (3)–(5) show that at the 1% level, cloud computing, blockchain, and digital technology can significantly and positively affect the level of enterprise SCF. Through cloud computing and digital technology, companies can monitor the entire supply chain in real time and realize visual management of the supply chain. This can help enterprises find problems, respond quickly, and improve the transparency and efficiency of the supply chain. Blockchain technology can improve the security and traceability of supply chain contracts, reduce contract risk, and reduce disputes. At the same time, the traceability management of products in the supply chain through blockchain technology is conducive to improving product quality and consumer trust. In general, the application of emerging technologies, such as

TABLE 4 Correlation tests.

Variable	*Scf*	*Dig*	*Lnasset*	*Lev*	*Roa*	*Top1*	*Dual*	*Tfp*	*Hhi*
Scf	1								
Dig	0.110***	1							
Lnasset	−0.096***	0.091***	1						
Lev	−0.568***	−0.092***	0.386***	1					
Roa	0.263***	0.00400	0.00200	−0.381***	1				
Top1	0.034***	−0.116***	0.181***	0.026***	0.144***	1			
Dual	0.025***	0.116***	−0.169***	−0.158***	0.054***	−0.045***	1		
Tfp	−0.177***	0.154***	0.762***	0.381***	0.109***	0.168***	−0.126***	1	
Hhi	0.040***	−0.014***	0.068***	0.042***	−0.034***	0.061***	−0.034***	0.037***	1

artificial intelligence, big data, cloud computing, blockchain, and digital technologies, in the field of enterprise SCF will help to improve the level of SCF, improve the efficiency, reliability, and transparency of the supply chain, and help enterprises reduce risks, optimize operations, and then enhance their competitiveness. Additionally, blockchain's support for deep-tier supply chain finance by extending credit to second- and third-tier suppliers addresses a gap that AI and cloud computing alone cannot fully resolve, as these technologies often focus on core enterprise interactions. The technology's inherent security and traceability also align with financial institutions' risk management priorities, making them more willing to extend SCF to digitized supply chains. The comparison shows that blockchain plays the most significant role in improving SCF levels.

To inspect the industry, we tested for industry heterogeneity by splitting the sample into manufacturing and service sectors. The results show that blockchain's positive impact on SCF is stronger in manufacturing ($\beta = 0.0024$, $p < 0.01$) than in services ($\beta = 0.0017$, $p < 0.01$). This industry difference likely arises because manufacturing supply chains are longer, involve more tiered suppliers, and have higher physical asset traceability, which are factors that amplify blockchain's value in enhancing transparency and reducing disputes. In contrast, service supply chains are often shorter and more intangible, limiting blockchain's ability to improve SCF through asset traceability. These findings suggest blockchain's superiority is context-dependent, with manufacturing firms standing to gain the most from its adoption.

From the inspection of firm size: The effect is more pronounced for small/mid-sized enterprises (SMEs, $\beta = 0.0020$, $p < 0.01$) than for large firms ($\beta = 0.0012$, $p < 0.01$). This suggests SMEs, which are often constrained by traditional SCF, benefit more from digital transformation, as it reduces information asymmetry and lowers financing barriers. These findings highlight the inclusive nature of digitalization-driven SCF improvement.

4.7 Lagged variable analysis for delayed impacts

To capture the delayed financial effects of digital transformation, we included lagged Dig variables ($Dig_{1\text{-}1}$, $Dig_{1\text{-}2}$, and $Dig_{1\text{-}3}$) in the regression model. Results show $Dig_{1\text{-}1}$ ($\beta = 0.0015$, $p < 0.01$) and $Dig_{1\text{-}2}$ ($\beta = 0.0013$, $p < 0.05$) remain positively significant, while $Dig_{1\text{-}3}$ is insignificant. This indicates digital transformation's impact on SCF persists for up to 2 years, reflecting the time required to fully implement digital systems, build trust with financial partners, and optimize SCF processes. The declining magnitude of coefficients over time (0.0017 for Dig, 0.0015 for $Dig_{1\text{-}1}$, and 0.0013 for $Dig_{1\text{-}2}$) suggests the initial adoption phase drives the strongest SCF improvements, with incremental gains in subsequent years. These results underscore the importance of long-term digital transformation strategies for sustained SCF enhancement.

5 Conclusion and prospects

This article presents a conceptual model illustrating how each digital transformation dimension maps to supply chain finance (SCF) outcomes. Artificial intelligence and big data drive SCF efficiency by automating credit evaluation and demand forecasting; cloud computing enables cross-party collaboration and real-time data sharing; blockchain enhances transaction security and traceability; and digital technology integrates these elements to reduce information asymmetry and transaction costs. Each dimension targets distinct SCF pain points. For example, AI addresses operational inefficiencies, while blockchain mitigates trust deficits. Together, they collectively elevate SCF accessibility and effectiveness.

The application of digital technology will have great significance and far-reaching impact on improving the level of SCF. With the wide application of digital technology in enterprises, the financial digitalization of supply chain operations has also become the

TABLE 5 Analysis of the benchmark regression results.

Variable	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7	Model 8
Dig	0.0016**	0.0004	0.0015**	0.0016***	0.0016***	0.0016***	0.0017***	0.0017***
	(0.0007)	(0.0007)	(0.0006)	(0.0006)	(0.0006)	(0.0006)	(0.0006)	(0.0006)
Lnasset		−0.0169***	0.0002	−0.0006	−0.0006	−0.0007	0.0012	0.0012
		(0.0010)	(0.0009)	(0.0009)	(0.0009)	(0.0009)	(0.0010)	(0.0010)
Lev			−0.3696***	−0.3588***	−0.3588***	−0.3588***	−0.3573***	−0.3572***
			(0.0037)	(0.0039)	(0.0039)	(0.0039)	(0.0039)	(0.0039)
Roa				0.0641***	0.0636***	0.0636***	0.0703***	0.0703***
				(0.0079)	(0.0080)	(0.0080)	(0.0083)	(0.0083)
Top1					0.0040	0.0042	0.0043	0.0042
					(0.0064)	(0.0064)	(0.0064)	(0.0064)
Dual						−0.0018	−0.0019	−0.0019
						(0.0014)	(0.0014)	(0.0014)
Tfp							−0.0041***	−0.0041***
							(0.0013)	(0.0013)
Hhi								0.0013
								(0.0049)
_cons	−0.1383***	0.2315***	0.0149	0.0261	0.0249	0.0258	0.0155	0.0154
	(0.0009)	(0.0216)	(0.0188)	(0.0189)	(0.0190)	(0.0190)	(0.0193)	(0.0193)
N	34,072	34,072	34,072	34072	34,072	34,072	34,072	34,072
adj.R^2	0.5836	0.5876	0.6893	0.6900	0.6900	0.6900	0.6898	0.6898
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

*,**, and***represent significance at 10%, 5%, and 1%, respectively; value clustering in brackets to the industry-level robust standard error.

current trend in supply chain development. Through the use of digital technology, enterprises can build an efficient and convenient trading platform, enhance the risk management ability, promote the innovation and upgrading of SCF, maximize the interests of all participants, improve the efficiency and competitiveness of the supply chain, and make positive contributions to the sustainable development of enterprises, the economy, and society.

The empirical results quantify the magnitude of digital transformation's impact on SCF: a one-unit increase in Dig (digital transformation) raises the SCF level by 0.0017, equivalent to 1.21% of the SCF mean (0.140). For a typical firm with 1 billion RMB in total assets, this translates to an approximate 1.7 million RMB increase in SCF availability. Blockchain, as the most impactful dimension, drives a 0.0021 increase in SCF per unit improvement, which is 17.6% higher than the average effect of other digital dimensions. These quantifiable outcomes demonstrate that digital transformation is not only a qualitative improvement but also a tangible driver of enhanced financial access for supply chain enterprises.

Based on the data of listed companies in the A-share non-financial industry from 2007 to 2021, there are many other factors influencing enterprise SCF. This article examines only the impact of digital transformation on enterprise SCF, and

TABLE 6 Results of the point-dimensional regression analysis.

Variable	(1)	(2)	(3)	(4)	(5)
	Model 1	Model 2	Model 3	Model 4	Model 5
Artificial intelligence	0.0011***				
	(0.0001)				
Big data		0.0012***			
		(0.0002)			
Cloud computing			0.0010***		
			(0.0001)		
Blockchain				0.0021***	
				(0.0001)	
Digital technique					0.0020***
					(0.0001)
Lnasset	0.0015	0.0014	0.0016	0.0015	0.0013
	(0.0010)	(0.0010)	(0.0010)	(0.0010)	(0.0010)
Lev	−0.3572***	−0.3571***	−0.3572***	−0.3572***	−0.3571***
	(0.0039)	(0.0039)	(0.0039)	(0.0039)	(0.0039)
Roa	0.0696***	0.0699***	0.0694***	0.0694***	0.0708***
	(0.0083)	(0.0083)	(0.0083)	(0.0083)	(0.0083)
Top1	0.0031	0.0032	0.0028	0.0028	0.0039
	(0.0064)	(0.0064)	(0.0064)	(0.0064)	(0.0064)
Dual	−0.0019	−0.0019	−0.0019	−0.0019	−0.0020
	(0.0014)	(0.0014)	(0.0014)	(0.0014)	(0.0014)
Tfp	−0.0037***	−0.0038***	−0.0037***	−0.0037***	−0.0042***
	(0.0012)	(0.0012)	(0.0012)	(0.0013)	(0.0013)
Hhi	0.0011	0.0012	0.0009	0.0011	0.0011
	(0.0049)	(0.0049)	(0.0049)	(0.0049)	(0.0048)
_cons	0.0088	0.0100	0.0068	0.0074	0.0158
	(0.0192)	(0.0192)	(0.0192)	(0.0193)	(0.0192)
N	34,018	34,018	34,018	34,018	34,018
adj.R^2	0.6898	0.6898	0.6898	0.6898	0.6899
Year FE	Yes	Yes	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes	Yes	Yes

*, **, and ***represent significance at 10%, 5%, and 1%, respectively; Standard errors clustered at the industry level are reported in parentheses.

only some internal influencing factors are selected as control variables. In the next step, more external factors can be included in the research scope to make it more comprehensive and specific.

Data availability statement

The original contributions presented in the study are included in the article/Supplementary Material; further inquiries can be directed to the corresponding author.

Author contributions

ZL: Data curation, Conceptualization, Writing – review and editing, Investigation, Writing – original draft, Software, Funding acquisition, Visualization. JZ: Investigation, Data curation, Supervision, Formal analysis, Project administration, Writing – original draft. LC: Writing – review and editing, Methodology, Data curation, Software. YX: Methodology, Supervision, Project administration, Funding acquisition, Writing – review and editing.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Correction note

A correction has been made to this article. Details can be found at: 10.3389/fphy.2026.1788972.

Generative AI statement

The authors declare that no Generative AI was used in the creation of this manuscript.

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