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Article

Supply Chain Finance, Fintech Development, and Financing Efficiency of SMEs in China

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Abstract: A long-term strategy for China's national development is to foster the growth of "Specialized, Refined, Niche, and Innovative (SRNI)" small and medium-sized enterprises (SMEs). However, these enterprises often face significant financing constraints due to their high technological input, high human capital input, light asset characteristics, and lack of effective collateral. Supply chain finance, as an important way to combine production and financing, could provide financial services in the real economy by alleviating these constraints of SMEs and improving the quality of credit so as to revitalize supply chain funds. This paper empirically examines the relationship between supply chain finance, fintech development, and financing efficiency using a sample of 757 "SRNI" SMEs in Shanghai and Shenzhen A-shares from 2013 to 2023. The findings reveal that supply chain finance significantly enhances the financing efficiency of "SRNI" SMEs. Moreover, the development of financial technology further amplifies such positive effects. This research contributes to the theoretical understanding of how supply chain finance and fintech impacts the financing efficiency of SRNI SMEs and provides valuable insights for evaluating SME financing efficiency.

Keywords: supply chain finance; financing efficiency; financial technology (fintech); small and medium-sized enterprises (SMEs); data envelope analysis (DEA)



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1. Introduction

China's Small and Medium-sized Enterprises (SMEs) have contributed significantly to the national economy and social development. Despite their significant contributions and considerable size, SMEs have faced numerous challenges, such as fluctuations in the macroeconomic environment, increasing supply chain uncertainty, and the pressure to reduce excess capacity. These obstacles hinder their transition to a "small but mighty" development model. In light of this developmental context, the Chinese government has instituted a series of policies. One aims to cultivate a group of "Specialized, Refined, Niche, and Innovative (SRNI)" SMEs that have niche markets, possess robust innovation capabilities, and are adept in key core technologies. These entities serve as pivotal conduits, enhancing supply chain resilience and competitiveness.

"Specialized, Refined, Niche, and Innovative" (SRNI) small and medium-sized enterprises (SMEs) embody four key characteristics: specialization, refinement, uniqueness, and innovation. "Specialized" refers to a focus on specialized development and niche markets, dedicating efforts to specific product applications. "Refined" emphasizes precision

and excellence in enterprise management, providing high-quality products and services. “Niche” highlights the distinct advantages of technology, processes, and products, showcasing regional characteristics and functional uniqueness. “Innovative” underscores strong innovation capabilities, adopting diverse and creative production methods, increasing investment in innovation, and enhancing overall innovation capacity.

However, the “SRNI” SMEs, characterized by their high technological and human capital inputs and asset-light attributes, face challenges in a number of ways. In terms of financing channels, SMEs primarily rely on credit loans and internal financing to address their funding shortages. However, these financing channels are relatively narrow and cannot fully meet the financing needs of SMEs. To mitigate the risks associated with fund delegation, fund providers must invest significant human, financial, and material resources to assess the financial status, creditworthiness, and market prospects before extending funds. Even after providing the funds, additional resources are required to monitor how the funds are utilized. This process leads to increased transaction costs, resulting in higher financing costs for SMEs. As for credit scale discrimination, larger financial institutions have a tendency to prioritize financing services for larger enterprises, while SMEs often encounter limited access to finance from commercial banking institutions. Similarly to credit scale discrimination, the distinctive characteristics of China’s socialist market economy leads to financing biases due to differences in property rights between borrowers and lenders. It is easier for state-owned enterprises to obtain credit from financial institutions than private enterprises (such as SMEs).

Consequently, in order to achieve the sustainable development of “SRNI” SMEs, it is imperative to identify a suitable “engine”, leveraging financial support to alleviate the technological innovation bottleneck and technological innovation to address the financing. Supply chain finance, a means of integrating production and financing, offers a potential solution. It is a financing model in which financial institutions, based on supply chain partnerships, provide financing, settlement, and other comprehensive financial services for their upstream and downstream enterprises around the core enterprises. The model aims to meet the capital demand and risk management needs of all parties in the supply chain. It has the potential to assist companies in enhancing their cash flow efficiency and addressing issues related to payment, financing, and credit risk across all segments of the supply chain. In academia, supply chain finance has garnered significant attention due to its capacity to alleviate the financing constraints experienced by SMEs. It has been shown to enhance the quality of credit, thereby revitalizing supply chain funds and facilitating the delivery of financial services to the real economy (Song et al., 2016).

There are many examples of using supply chain finance to address the financing challenges of SMEs. For example, a supply chain finance model led by Ant Group, in collaboration with MYbank and China Continent Property and Casualty Insurance, involves leading supply chain companies such as Mengyang Group, Kerchin Cattle Industry, and Yiguo Fresh. It provides supply chain financial services ranging from loans to sales for upstream large-scale breeding enterprises and downstream agricultural material sales enterprises, significantly improving the financing efficiency of the entire supply chain partners (Y. Wang & Mao, 2019).

While the previous case shows the promising role of supply chain finance, the purpose of this study is to empirically investigate the relationship between supply chain finance and financing efficiency using a larger dataset, particularly in a sample of “SRNI” SMEs. In addition, this study explores the role of financial technology in such a relationship.

Data from 757 listed “SRNI” SMEs in Shanghai and Shenzhen A-shares from 2013 to 2023 are used in a panel data analysis to test the corresponding hypotheses. The findings indicate that implementing supply chain finance can substantially enhance the financing

efficiency of “SRNI” SMEs. Furthermore, this study suggests that advanced regional fintech positively moderates the effect of supply chain finance and financing efficiency. This conclusion remains consistent after conducting an endogeneity test, ensuring the robustness of the findings.

The results offer a promising solution to the survival and success of SMEs. It not only enriches the theoretical research on the impact of supply chain finance on the financing efficiency of SMEs but also generates crucial policy implications and guidance on the sustainable development of “Specialized, Re-fined, Niche, and Innovative” SMEs.

The remainder of this paper is organized as follows. Section 2 provides a relevant literature review on this topic. Section 3 contains the theoretical development of the hypotheses. Section 4 describes the methodology, while Section 5 presents the analysis and results. Section 6 concludes this study with contributions, implications, and limitations.

2. Literature Review

2.1. Supply Chain Finance

The core objective of supply chain finance is to optimize the capital flow mechanism among enterprises by leveraging solutions offered by financial institutions and technical service providers. From the perspective of the entire supply chain, it enhances the management of capital flow and drives the rapid development of industrial supply chains through financial business innovation and advanced management tools. The research focus of supply chain finance literature primarily concentrated on the micro level of enterprises, encompassing the following three dimensions.

First, existing studies primarily focus on analyzing the economic effects of supply chain finance to evaluate its effectiveness in alleviating financing constraints. For instance, L. Wang and Hu (2018) incorporated elements such as industry–finance integration and strategic commitment into the comprehensive analysis system of supply chain finance and corporate financing constraints. Their results reveal that supply chain finance has a significant negative effect on financing constraints of enterprises, meaning it effectively alleviates financing constraints. Additionally, both industry–finance integration and strategic commitment play a significant positive moderating role in the relationship between supply chain finance and the financing constraints of enterprises.

In studying how supply chain finance enhances financing effectiveness, scholars have conducted in-depth analyses of its specific impact on financing cost and financing efficiency of SMEs from both qualitative and quantitative dimensions. Based on social network theory, X. Li et al. (2020) constructed a theoretical model examining the relationship between sustainable supply chain finance, environmental regulation, and financing effectiveness. They empirically validated this model using survey data from 386 SME executives. The results indicate that sustainable supply chain finance significantly contributes to the financing effectiveness of SMEs across all three dimensions: economic, social, and environmental.

Second, some studies have explored the risk control mechanism of supply chain finance. The execution of financial credit business is often accompanied by risks, and its transferable, dynamic, and complex nature may expose the financing system of supply chains to uncertainty. Su and Lu (2015) employed cluster analysis to classify companies into different levels and introduced an adaptive weight formula for each level based on the number and degree of attention to that level while considering the characteristics of corporate supply chain networks. They found that the enterprise-level credit risk assessment with higher attention carries a greater weight in the overall credit risk assessment of the supply chain system, thereby exerting a more significant impact on the supply chain.

Building on the general framework of supply chain risk management, Song and Yang (2018) approached the risk management problem of supply chain finance from three

dimensions—structure, process, and elements—to effectively address various sources of risks and achieve desired financing performance. Wan (2008) found that the risk mitigation mechanisms integral to supply chain finance are susceptible to failure through an examination of the risk model associated with accounts receivable financing. They emphasized the need for banks to establish a new type of cooperative relationship with the core enterprises and leverage their respective strengths to fulfill the role of supply chain finance.

Third, some of the literature explores the operational strategies of supply chain finance, including financing strategies, transaction strategies, inventory management strategies, and production strategies. Among them, numerous studies consider the interplay of production decisions, inventory decisions, transaction decisions, and financing decisions within the context of dual supply chain finance constraints. From the perspective of external financing, Buzacott and Zhang (2004) highlighted the importance of production and external financing decisions to the business environment by incorporating a financing element into the production decision and modeling the available cash in each period as a function of assets and liabilities.

Yan and Sun (2011) investigated the optimal warehouse receipt pledge financing strategy for capital-constrained retailers within supply chain finance systems under demand uncertainty. Through numerical examples, they analyzed the effects of varying credit limits of retailers on the optimal strategy of the supply chain finance system and concluded that the limited credit limit financing scheme can motivate the supply chain finance system to increase order quantities and provide effective financing incentives for risk-taking retailers.

2.2. Efficiency of Corporate Finance

In the context of enterprise financing efficiency, scholars have not yet provided a clear and unified definition of the efficiency of corporate finance. Research has mainly focused on the relationship between financing methods and enterprise performance. Klapper et al. (2002) argued that the choice of financing methods—equity, bonds, or endogenous—results in different financing costs, which, in the long run, will affect the enterprise's future financing efficiency. Jain and Kini (1994) found that there is a significant decline in the operating performance of enterprises following initial public offering, indicating a general inefficiency in equity financing. Bradford and Chen (2004) studied the financing efficiency of science and technology SMEs, concluding that financing through loan guarantees is more efficient than direct loans provided by the Chinese government.

Xiao and Ma (2004) believed that financing efficiency includes transaction efficiency and allocation efficiency. They emphasized that investors should be able to obtain financial resources at the lowest cost while utilizing limited resources for optimal production. Zhang and Zhao (2015) further refined the concept of financing efficiency, defining it as the ability of an enterprise to secure financial capital with the optimal benefit–cost ratio and the lowest risk during financing activities.

Factors affecting corporate financing efficiency can be categorized into macro and micro factors. Macro-level factors include the economic environment, political environment, information environment, financial environment, and so on. Xiong et al. (2011) concluded that the development of strategic emerging industries is significantly influenced by the macroeconomic environment, and the factors affecting financial support efficiency exhibit stage-specific characteristics: emerging industries related to low-carbon technologies achieved better financial support efficiency, while the high-end equipment manufacturing sector faced challenges in this regard. They concluded that the better the macroeconomic situation is, the higher the efficiency of financial support the industry receives from the financial market. On the micro-level, firm-specific factors such as financing structure,

firm size, governance structure, profitability, and solvency also play significant roles in determining financing efficiency.

S. Wang (2014) argued that state-owned enterprises (SOEs) are comparatively less efficient in financing than privately owned and foreign-invested firms. Cui et al. (2014), based on the construction of the financing efficiency calculation model, utilized financial data from non-listed SMEs to conduct a dynamic factor panel data model analysis, comprehensively examining the factors influencing the financing efficiency of non-listed SMEs. Their findings revealed that the company's intrinsic quality and core business conditions have a significant impact on its profitability, the short-term exogenous debt funding sources, their size and liquidity, and the company's solvency capacity generally play crucial roles. However, the effect of commercial credit financing costs was found to be insignificant.

2.3. Financial Technology

In the 1990s, the term “financial technology” was first mentioned by the Chairman of Citigroup (X. Li et al., 2020). Through continuous enrichment and expansion by academia and industry, financial technology (fintech) has been defined as technology-driven financial innovation. Specifically, it refers to financial innovation that leverages cutting-edge technologies to facilitate information exchange between banks and enterprises, transform the delivery of financial products and services, and foster new business models (X. Li et al., 2020). The application of emerging technologies in the financial sector has effectively reduced information asymmetry in financial markets, streamlined traditional financial service processes, and lowered financing risks and transaction costs (Goldstein et al., 2019).

The impact of fintech on supply chain finance and financing efficiency can be argued in a number of ways. First, fintech affects the efficiency of industry–finance integration. From the industry side, Chod et al. (2020) proposed that fintech can enhance the authenticity and transparency of information related to the business flow, logistics, and capital flow of small and medium-sized enterprises in the supply chain. This helps financial institutions, such as commercial banks, recognize their development potential, thereby increasing financing accessibility and enhancing financing efficiency. From the capital side, Berger and Udell (2006) argued that fintech enables banks to gather more comprehensive “soft” information, improve the efficiency of credit assessment, and boost financing efficiency.

Second, fintech influences the way financial services are delivered. X. Wang (2015) believed that fintech has driven the development of credit business towards batch processing, intelligence, and intensification, significantly reducing the application and approval processes, thereby improving the efficiency of bank-enterprise credit handling. Huang et al. (2020) proposed that fintech significantly reduces the transaction and processing costs for banks to provide financial services to SMEs; this helps SMEs reduce financing costs, thereby enhancing the level of supply chain financing.

Finally, fintech influences risk prevention and control capabilities. Emerging technologies such as big data, cloud computing, and blockchain facilitate information sharing and collaborative development among multiple entities in supply chains. This effectively reduces information asymmetry, lowers credit risks for banks, and improves the accessibility of supply chain financing. Sutherland (2018) investigated how credit reporting affects firms' access to credit and how lenders engage with them. The findings highlight the mixed effects of fintech-driven transparency enhancements on credit availability.

2.4. Research Gaps

The review of the literature shows at least a few gaps. First, content-wise, existing studies predominantly concentrate on supply chain finance models, their influence on operational efficiency, and their role in mitigating financing constraints. However, there

is a notable gap in the quantitative analysis of how supply chain finance affects financing efficiency. This study addresses this gap by utilizing the Data Envelopment Analysis (DEA) model to quantify financing efficiency and employing linear regression to directly measure the extent of this impact. Second, in terms of the research subject, existing research often involves a wide range of complex subjects, which unavoidably brings in company-specific noises and may contaminate the results. This study narrows its focus to a specific type of enterprises—“Specialized, Refined, Niche, and Innovative” (SRNI) SMEs. Such enterprises are characterized by their high technological content, significant human capital investment, and light asset structure, making their financing challenges more prominent and pertinent to contemporary issues. Third, existing studies have shown that fintech can enhance supply chain finance’s transparency, efficiency, and security, thereby better-serving SMEs. This paper further explores the “catalytic role” of fintech in supply chain finance, optimizing various aspects of supply chain finance through technological innovation, thereby more effectively addressing the financing challenges faced by SMEs.

3. Theoretical Development of Hypotheses

3.1. Supply Chain Finance and Financing Efficiency

Financing efficiency is the result of the combined impact of capital input and output, which is specifically affected by the cost of capital acquisition and the efficiency of capital utilization. “Specialized, Refined, Niche, and Innovative” SMEs have to bear higher financing costs due to their inherent weakness, small scale, information asymmetry, and other vulnerabilities. Therefore, they often struggle to secure the necessary funds, leading to low financing efficiency. This, in turn, impedes their research and development (R&D) efforts and negatively affects their long-term sustainable development.

In terms of capital investment, supply chain finance addresses the issue of high financing costs for “SRNI” SMEs in the following three aspects. First, supply chain finance uses the core enterprise as a guarantor for SMEs, enabling them to secure financing. This approach effectively mitigates the financing difficulties of SMEs due to poor credit conditions while maintaining much flexibility. Second, supply chain finance extends its services to multiple enterprises within the supply chain. Such system integration increases information transparency, fosters greater cooperation among enterprises, and reduces risks throughout the financing process. Third, supply chain finance is an effective financing mechanism that can significantly reduce the high risk of default due to information asymmetry. Rooted in actual trade activities, it extends credit evaluation to the whole supply chain process, takes into account the actual needs of enterprises, monitors the circulation of goods, and allows financial institutions to participate in the utilization of funds directly. Therefore, the introduction of supply chain finance into the entire supply chain can reduce the cost of obtaining funds and alleviate the financing difficulties for “SRNI” SMEs.

From the output perspective, supply chain finance, grounded in self-paying and closed-loop capital operations, can effectively control risks and improve the efficiency of capital utilization by coordinating financial and industrial resources. In addition, supply chain finance forms an open information-sharing model through a long-term partner cooperation network. It provides dynamic data change prediction and accelerates the flow of information, capital, and other elements between upstream and downstream enterprises. Not only does the model optimize supply chain operations, but it also boosts the innovation performance and product market competitiveness of “SRNI” SMEs, thereby creating a multiplier effect between industrial and financial benefits. According to these arguments, supply chain finance enables “SRNI” SMEs to improve the efficiency of capital mobilization by reducing the marginal cost of financing while promoting the efficient utilization of integrated capital. Accordingly, we propose the following hypothesis.

H1. *The development of supply chain finance can promote the financing efficiency of “Specialized, Refined, Niche, and Innovative” SMEs.*

3.2. The Role of Fintech

Against the backdrop of the rapid development of digital technology, fintech is transforming the management and operation mode of the financial industry. Empowered by cutting-edge technologies such as cloud computing, big data, and mobile information technology, fintech has overhauled the traditional financial services industry all around, restructuring and optimizing the traditional financial business, and providing more convenient, efficient, and secure financial services (Buchak et al., 2018).

First of all, by leveraging emerging technologies, fintech can help financial institutions gain a more comprehensive understanding of the business situation and creditworthiness of enterprises, which is more conducive to integrating the situation of upstream and downstream enterprises in the supply chain and promoting the development of supply chain finance.

Second, with the help of emerging technologies, fintech can break through the spatial limitations of the traditional financial sector and increase the supply of funds in the credit market. Fintech provides a wider range of financial products and services to enterprises in different regions through cross-regional financing platforms, thus expanding enterprises' financing channels. Easing the constraints of enterprises in the financing process creates better conditions for the development of supply chain finance and further promotes the development of financing efficiency of “SRNI” SMEs.

Finally, financial technology's intelligent and informative functions can also help financial institutions supervise the use of enterprises' post-loan funds, improve the efficiency of post-loan supervision, and reduce moral risks. In conclusion, developing financial technology can reduce the financing cost of “SRNI” SMEs and improve their financing efficiency. Based on this, we put forward the following hypothesis:

H2. *Fintech development positively moderates supply chain finance and the financing efficiency of “Specialized, Refined, Niche, and Innovative” SMEs.*

4. Methodology

4.1. Sample Selection and Data Sources

Since the Ministry of Industry and Information Technology (MIIT) first issued the “Guiding Opinions on Promoting the Development of ‘SRNI’ SMEs” in June 2013, we set 2013 as the starting year of the development of “SRNI” SMEs. Using the list of “Specialized, Refined, Niche, and Innovative” enterprises published by the MIIT from 2014 to 2024, we filtered out the listed companies and generated a sample of 1193 SRNI small and medium-sized enterprises listed on the Shanghai and Shenzhen A-shares from 2013 to 2023. To ensure the sample was relevant and meaningful to our research questions, we further excluded companies in the financial industry, those with an ST trading status in the current year, those listed for less than one year, and those with missing financial data. This left us with a final sample of 757 listed companies, comprising 4717 observations over 10 years.

The data in this paper primarily comes from the China Stock Market and Accounting Research Database (CSMAR) database. The CSMAR Database is a comprehensive and authoritative financial database designed to support academic research and practical analysis in the fields of economics, finance, and accounting. CSMAR is widely used by researchers, analysts, and institutions globally due to its extensive data coverage, accuracy, and reliability (He et al., 2022). The database includes detailed financial statements, stock

market trading data, corporate governance information, and specialized datasets such as supply chain finance, ESG metrics, and more.

The fintech data in this paper is sourced from the Peking University Digital Inclusive Finance Index (PKU-DFI). The PKU-DFI is a comprehensive and influential index developed by the Institute of Digital Finance at Peking University in collaboration with Ant Group. It measures the development and accessibility of digital financial services across China, focusing on promoting financial inclusion through technology. This paper uses the provincial level fintech index.

4.2. Research Model and Variable Measurements

Panel data analysis is conducted using the fixed effect estimation method (analyzed with STATA). The fixed effect model can control for time-invariant individual-specific characteristics (such as corporate culture, geographic location, etc.), thereby reducing omitted variable bias and improving the accuracy of estimation results. Additionally, STATA provides robust standard errors to effectively address issues of heteroskedasticity and autocorrelation.

Model 1 is used to test research H1: the relationship between supply chain finance (SCF) and financing efficiency (*Fineff*) of “SRNI” SMEs.

$$Fineff_{i,t} = \beta_0 + \beta_1 SCF_{i,t} + \sum \beta_j Control_{i,t} + \gamma_{i,t} + \eta_{i,t} + \varepsilon_{i,t} \quad (1)$$

Model (2) introduces moderating variables to test H2: the moderating effect of fintech (*FinTech*) development on the relationship between supply chain finance and the financing efficiency of “SRNI” SMEs:

$$Fineff_{i,t} = \beta_0 + \beta_1 SCF_{i,t} + \beta_2 FinTech_{p,t} + \beta_3 SCF_{i,t} \times FinTech_{p,t} + \sum \beta_j Control_{i,t} + \gamma_{i,t} + \eta_{i,t} + \varepsilon_{i,t} \quad (2)$$

in which i for SME, t for year, p for province, $\gamma_{i,t}$ industry fixed effects, $\eta_{i,t}$ year fixed effects, and $\varepsilon_{i,t}$ random error terms.

There are three common measurement methods for the dependent variable—financing efficiency (*Fineff*): (1) fuzzy evaluation method and entropy value method; (2) single ratio method; and (3) data envelopment analysis (DEA) method. We chose to use DEA method for two reasons. DEA is a non-parametric method for evaluating the relative efficiency of decision-making units (DMUs) with multiple inputs and outputs. By employing linear programming, DEA constructs an efficient frontier, which serves as a benchmark for comparing the performance of each DMU. The DEA model avoids errors caused by inappropriate functional form assumptions and allows for cross-sectional comparisons of financing efficiency across firms with different scales and units (Zhang et al., 2020). In addition, the DEA approach has been widely used to measure financing efficiency (Sun et al., 2023; Yang et al., 2023).

Drawing on the research of F. Li and Wang (2014), we used DEAP 2.1 (a DEA APP) to calculate the annual financing efficiency of enterprises, with efficiency scores ranging between 0 and 1. The input indicators include total assets, asset–liability ratio, and main business costs, while the output indicators include return on net assets, total asset turnover, and operating income growth rate.

The independent variable in this paper is supply chain finance (SCF). The measurement of supply chain finance follows the study of Liu et al. (2024). We adopt micro-level continuous proxy variables at the enterprise level and use the sum of short-term borrowings, notes payable, and accounts payable as a proportion of total assets as a proxy for supply chain finance. This measurement is chosen because the “financial attributes” of supply chain finance are primarily reflected in short-term financing tools for supply chain transactions, which alleviate financing constraints for SMEs through short-term borrowings. Meanwhile,

notes payable and accounts payable reflect the characteristics based on upstream and downstream trade relationships, highlighting the role of core enterprises as financing intermediaries and credit subjects.

The moderating variable in this paper is financial technology (*FinTech*). We adopt the Peking University Digital Financial Inclusion Index as a proxy for fintech. Fintech can be defined as the use of technological means to innovate products and services in the traditional financial industry, aiming to improve efficiency and reduce operating costs. The Peking University Digital Financial Inclusion Index is generated by analyzing massive data from fintech enterprises as a third-party index. This index covers the development of digital financial inclusion across various provinces and regions in China. Moreover, it evaluates three main dimensions: coverage breadth, usage depth, and digitalization level, providing a comprehensive reflection of the overall development of digital finance. Given that the index values are generally above 100, while the financing efficiency data ranges from 0 to 1, this paper divides the Peking University Digital Financial Inclusion Index by 100 to ensure the interpretability of the index values.

This paper utilizes extant studies (Tang et al., 2019) to select the following firm characteristic variables as control variables: return on total assets (*ROA*), top ten shareholders' ownership (*TopTenH*), cash to assets ratio (*Cash*), long term capital gearing (*Lcg*), enterprise size (*Assets*), equity ratio (*Equity*), and revenue growth rate (*Rgr*). The continuous variables are winsorized at 1% and 99% to reduce outlier effects.

Table 1 summarizes the key variables and their measurements.

Table 1. Key variables and measurements.

Variable Type	Variable Name	Symbol	Measurement
Dependent Variable	Financing efficiency	<i>Fineff</i>	DEA model calculations
Independent Variable	Supply chain finance	<i>SCF</i>	(Short-term loans + notes payable + accounts payable)/total assets
Moderator variable	Financial technology development	<i>FinTech</i>	Peking University Digital Inclusive Finance Index/100
Control variable	Return on total assets	<i>ROA</i>	Net profit/total assets
	Shareholding ratio of top ten shareholders	<i>TopTenH</i>	Sum of shareholdings ratio of top ten shareholders
	Ratio of cash assets	<i>Cash</i>	(Cash and cash equivalents)/total assets
	Long-term capital gearing	<i>Lcg</i>	Non-current liabilities/(non-current liabilities + shareholders' equity)
	Enterprise size	<i>Assets</i>	Logarithmic total assets of the enterprise
	Equity ratio	<i>Equity</i>	Total liabilities/shareholders' equity
	Revenue growth rate	<i>Rgr</i>	(Current year's operating income/previous year's operating income) – 1

4.3. Descriptive Statistics

Table 2 reports the descriptive statistics of the key variables. The maximum value of financing efficiency (*Fineff*) is 1 and the minimum value is 0.034. Its mean value is 0.406, and the standard deviation is 0.209, which indicates a big difference in the financing efficiency of different enterprises. The supply chain finance index (*SCF*) has a mean value of 0.178 and a maximum value of 0.775, indicating that there is a significant left bias in the data. In addition, the rest of the control variables of enterprise characteristics are within a reasonable range, but show volatility to a certain extent, indicating that there is a certain degree of heterogeneity among enterprise characteristics, which provides a possibility for subsequent research.

Table 2. Descriptive statistics of the key variables.

Variables	Mean	SD	Min	P25	Median	P75	Max
<i>Fineff</i>	0.406	0.209	0.034	0.256	0.366	0.513	1.000
<i>SCF</i>	0.178	0.127	0.000	0.078	0.154	0.254	0.775
<i>FinTech</i>	353.237	84.562	115.100	295.760	368.440	418.340	498.280
<i>ROA</i>	0.042	0.066	−0.243	0.017	0.045	0.076	0.211
<i>TopTenH</i>	59.427	15.095	12.330	48.680	60.310	70.930	100.000
<i>Cash</i>	0.184	0.136	0.011	0.083	0.150	0.246	0.655
<i>Lcg</i>	0.088	0.116	0.000	0.013	0.039	0.119	0.987
<i>Assets</i>	21.489	0.815	19.797	20.898	21.440	21.988	23.842
<i>Equity</i>	0.765	3.432	0.011	0.216	0.415	0.784	186.114
<i>Rgr</i>	0.321	1.532	−2.780	−0.028	0.121	0.374	65.498

5. Empirical Analysis and Results

5.1. Results of Model 1

Model 1 was performed to test the first hypothesis, and the results are shown in Table 3. When controlling industry and year-fixed effects, the coefficient of supply chain finance is significantly positive, i.e., when supply chain finance is increased by 1 percentage point, its financing efficiency is increased by 0.1894 percentage points. It can be seen that the regression coefficient of supply chain finance (*SCF*) on the financing efficiency of “SRNI” SMEs is significantly positive at the 1% level, indicating that the development of supply chain finance can promote the financing efficiency of “SRNI” SMEs and alleviate the problem of financing difficulties of “SRNI” SMEs, and at the same time, enhance the efficiency of their utilization of financing funds and the hypothesis H1 is supported. By leveraging the credit endorsement of core enterprises and real transaction data from the supply chain, supply chain finance could reduce the risk assessment costs for financial institutions. It also enables SMEs to access lower-interest financing, optimizes capital flow within the supply chain, shortens the cash conversion cycle, and improves capital utilization efficiency. Supply chain finance provides stable financial support to “SRNI” SMEs, allowing them to allocate more resources to technology development and innovation.

Table 3. Panel data fixed effect model results.

Variables	Model 1	Model 2
<i>SCF</i>	0.1894 *** (2.8040)	0.2170 *** (3.6443)
<i>FinTech</i>		−0.0010 ** (−2.5158)
<i>SCF</i> × <i>FinTech</i>		0.0016 *** (4.9359)
<i>ROA</i>	1.6543 *** (18.4221)	1.6468 *** (18.6321)
<i>TopTenH</i>	0.0013 ** (2.2287)	0.0013 ** (2.3446)
<i>Cash</i>	0.0840 ** (2.4167)	0.0634 * (1.8646)
<i>Lcg</i>	0.0983 ** (2.1975)	0.0750 (1.6471)
<i>Assets</i>	−0.0142 (−1.3687)	−0.0067 (−0.6783)
<i>Equity</i>	0.0016 ** (2.4610)	0.0017 ** (2.3783)

Table 3. Cont.

Variables	Model 1	Model 2
<i>Rgr</i>	0.0107 ** (2.0712)	0.0107 ** (2.0667)
<i>_cons</i>	0.6298 *** (2.7324)	0.6615 *** (2.7250)
<i>year</i>	Yes	Yes
<i>ind</i>	Yes	Yes
N	4717	4717
Within R ²	0.3638	0.3725

Notes: *, **, and *** denote two-tailed (one-tailed when there is a predicted sign) statistical significance at the 10%, 5%, and 1% levels, respectively.

5.2. Results of Model 2

In the moderating effect model (Model 2), we focus on the results of the interaction term between supply chain finance and fintech development ($SCF \times FinTech$). If the test result of such interaction term is significantly positive, it means that fintech development plays a positive role between supply chain finance and financing efficiency of “SRNI” SMEs, and conversely, it plays a negative role.

The results of model (2) appear in Table 3; the results show that the coefficient of the interaction term is 0.0016, which is significantly positive at 1% significance level, indicating that the level of fintech development plays a positive role in the financing efficiency of SMEs. Fintech development acts like a catalyst to enhance the promotion effect of supply chain finance on financial efficiency, and Hypothesis 2 is verified. In practice, fintech innovations and digital solutions can optimize supply chain finance processes, effectively addressing the financing challenges of SMEs. Technologies such as blockchain and big data enable real-time recording and sharing of transaction data, enhancing information transparency. Big data analytics and artificial intelligence allow faster and more accurate assessments of SMEs’ credit risk and repayment capacity, providing tailored financing solutions to meet their needs.

5.3. Endogeneity Test—Instrumental Variable Approach

In order to address the potential endogeneity issues that can lead to biased and inconsistent estimates of the regression coefficients, we employed the instrumental variable approach to check the robustness of the results.

We introduced supply chain finance lagged one period ($L.SCF$) as the instrument variable for the independent variable (SCF). Instrumental variable regression was performed using the two-stage regression model 2SLS. The outcomes of the instrumental variables test demonstrate that the Cragg–Donald Wald F statistic is 255.98, which is considerably larger than the critical value of 10, indicating that there is no weak instrumental variables problem. The p -value of Sargan’s test is 0.26, which is larger than the critical value of 0.1, suggesting that there is no necessity to perform an over-identification test at this juncture in the process and that there is no over-identification problem.

The first stage of the regression analysis was conducted between the instrumental variable ($L.SCF$) and SCF . The estimated coefficient of $L.SCF$, shown in column (1) of Table 4, is significantly positive at the 1% level. The result suggests that this instrumental variable is desirable and can be tested in the subsequent step. Column (2) shows the results of the second stage regression, in which the projected value of SCF serves as the independent variable. The regression coefficient (0.1892) is still significant and positive at the 1% level.

The results are consistent with Section 5.1, indicating that supply chain finance positively affects the financing efficiency of “SRNI” SMEs.

In a similar vein, an instrumental variables test is conducted to test the moderating effect of *FinTech*. The third column of Table 4 presents the first-stage regression results, with the estimated coefficient of *L.SCF* found to be significantly positive at the 1% level when the moderator (*FinTech*) and the interaction term ($SCF \times FinTech$) are introduced. These findings suggest that this instrumental variable is desirable and can be tested in the subsequent step. Column (4) presents the second-stage regression results. The regression coefficient of the interaction term is 0.0008, significantly positive at the 1% level of significance. The research results are consistent with Section 5.2, indicating that the advancement of fintech could generate a promotion effect of supply chain finance on financing efficiency for “SRNI” SMEs.

Table 4. Instrumental variable tests.

Variables	(1) SCF	(2) Fineff	(3) SCF	(4) Fineff
<i>L.SCF</i>	0.8349 *** (0.009)		0.8344 *** (0.009)	
<i>SCF</i>		0.1892 *** (0.028)		0.1774 *** (0.028)
<i>FinTech</i>			0.0000 (0.000)	0.0001 *** (0.000)
$SCF \times FinTech$			0.0000 (0.000)	0.0008 *** (0.000)
<i>ROA</i>	−0.1476 *** (0.015)	1.6549 *** (0.043)	−0.1475 *** (0.015)	1.6553 *** (0.043)
<i>TopTenH</i>	0.0001 ** (0.000)	0.0006 *** (0.000)	0.0001 ** (0.000)	0.0006 *** (0.000)
<i>Cash</i>	−0.0780 *** (0.008)	0.0389 * (0.024)	−0.0777 *** (0.008)	0.0441 * (0.024)
<i>Lcg</i>	−0.0301 *** (0.009)	0.0394 (0.026)	−0.0302 *** (0.009)	0.0362 (0.026)
<i>Assets</i>	0.0033 ** (0.001)	0.0108 *** (0.004)	0.0033 ** (0.001)	0.0115 *** (0.004)
<i>Equity</i>	0.0002 (0.000)	0.0035 *** (0.001)	0.0002 (0.000)	0.0036 *** (0.001)
<i>Rgr</i>	0.0020 *** (0.001)	0.0009 (0.002)	0.0020 *** (0.001)	0.0009 (0.002)
_cons	−0.0688 ** (0.032)	−0.0591 (0.088)	−0.0697 ** (0.033)	−0.0787 (0.088)
N	4075	4075	4075	4075
Within R ²	0.801	0.385	0.801	0.386

Notes: *, **, and *** denote two-tailed (one-tailed when there is a predicted sign) statistical significance at the 10%, 5%, and 1% levels, respectively.

6. Conclusions and Policy Implications

6.1. Conclusions

A comparison of supply chain finance with traditional finance reveals that the former is a systematic financing arrangement between enterprises and banks for all member enterprises of the supply chain. It prioritizes the multidimensional summarization and utilization of enterprise information, a strategy that is more conducive to alleviating financial constraints faced by enterprises and promoting technological transformation and upgrading. The development and expansion of supply chain finance have led to its emergence as a significant instrument in supporting the real economy.

The advent of supply chain finance has provided substantial assistance for the collaborative development of upstream and downstream sectors within the industry. For example, Ouyeel, a supply chain finance platform under Baowu Group, focuses on the steel industry. Baowu Group, together with leading enterprises such as Sinotrans and Taiyuan Iron and Steel (Group) Co., Ltd. (TISCO), connects Ouyeel e-commerce and Ouyeel Logistics on one end, and banks such as Industrial and Commercial Bank of China (ICBC) and China Construction Bank (CCB) on the other end. It provides supply chain finance, e-commerce transaction services, and information services to all raw material suppliers, steel production enterprises, mid- and downstream distributors, and end customers, thereby enhancing financing efficiency for all participating enterprises.

This study employs Shanghai and Shenzhen A-share-listed “Specialized, Refined, Niche, and Innovative” SMEs (2013–2023) as research samples to investigate the interplay among supply chain finance, fintech development, and SMEs’ financing efficiency. Through a systematic literature review, we formulate two hypotheses and derive the following empirically validated conclusions: (1) SCF exhibits a significant positive impact on the financing efficiency of SRNI SMEs, demonstrating its capacity to reduce capital expenditures while generating a multiplier effect between industrial and financial returns; (2) fintech advancement amplifies SCF’s efficacy in enhancing SME financing efficiency. Both findings withstand the endogeneity test, confirming the robustness of our analysis.

6.2. Research Implications and Recommendations

Supply chain finance is fundamentally a collaborative endeavor among multiple parties, involving the flow of capital through the supply chain nodes. The objective is to enhance the efficiency of enterprise financing. It is imperative for members of the supply chain to adhere to the principle of “all glory, all loss” and to leverage the win–win mechanism of supply chain cooperation. The integration of fintech into supply chain and industrial chains facilitates the streamlining of financial integration processes within industrial contexts, thereby offering a potential solution to the prevailing challenges experienced by the real economy. The integration of emerging information technologies into the traditional financial sector has led to significant benefits for small and medium-sized enterprises in the form of supply chain financing.

This study provides the following implications. First, supply chain finance has demonstrated its stability and durability, which can effectively address the financing problems encountered by “Specialized, Refined, Niche, and Innovative” SMEs in their operation and management, and thus enhance the efficiency of capital allocation among and within enterprises. Participation in supply chain finance activities provides these enterprises with low-cost and stable capital channels, thereby injecting sustained vitality into the development of their primary business. This, in turn, facilitates the movement of capital from the virtual realm to the real economy, promoting enterprises to realize cost reduction and efficiency improvement.

Second, in order to promote the development of supply chain finance, it is necessary to focus not only on the financial value of supply chain finance, but also on its industrial value. In addition, it is essential to ensure the efficient operation of capital flow, information flow, and logistics through the construction of a modernized circulation system. This will ultimately enhance the value of the entire supply chain. For “SRNI” SMEs, it is essential to deepen their collaboration with financial institutions according to their unique development needs, conditions, and industry trends. These SMEs should proactively explore novel modes of supply chain finance, leverage the financial support available, and accurately promote the profound integration of technological innovation and production and operation links.

In accordance with the research implications, we propose the following recommendations. At the government level: governments could introduce more policies to support the development of supply chain finance, such as tax incentives and risk compensation funds, to encourage financial institutions and core enterprises to participate. Such a policy can reduce the operational costs of supply chain finance and enhance the participation of all parties, thereby better-serving SMEs.

To supply chain partners: Core enterprises along the supply chain can actively engage in supply chain finance by providing credit endorsement and financing support to upstream and downstream SMEs with growth potential. SMEs should strengthen internal management, establish robust financial and accounting systems, and ensure data accuracy and transparency. Strong internal management can improve SMEs' credit ratings and build trust with financial institutions. They should also explore suitable supply chain finance models based on their development needs.

As for financial institutions, they should develop more customized supply chain finance products tailored to the characteristics of SMEs, such as accounts receivable financing, inventory financing, or order-based financing. Fintech companies should create more supply chain finance solutions for SMEs, such as AI-based risk assessment tools or blockchain platforms.

6.3. Research Limitations

While this study offers insights into the interaction of supply chain finance, fintech, and financing efficiency, there are several limitations. First, there is still much improvement in the measurement. For instance, we employed a single ratio method to measure supply chain finance, which might introduce potential measurement bias. Future studies could consider using text analysis to improve the measurement method by collecting publicly available textual data from enterprises, such as annual reports, social responsibility reports, press releases, and announcements, extract keywords related to supply chain finance (e.g., supply chain finance, accounts receivable financing, accounts payable financing, factoring, and core enterprises), and use natural language processing (NLP) techniques to statistically analyze the frequency or weight of these keywords in the text, serving as a proxy variable for supply chain finance activities. Text analysis can comprehensively capture information and reflect the dynamic changes in enterprises' supply chain finance activities. Second, while we targeted SRNI SMEs to reduce the company-specific noises that may contaminate the results, this unavoidably limits the generalizability of the conclusions to all SMEs (including private firms). Third, there is a lack of control over the impact of macroeconomic and policy changes. Our study only controls firm-level data and does not account for the influence of macro policy changes. Given that the supply chain finance industry is continuously evolving, national macro policy adjustments and banking policies may change at any time. Incorporating controls for these factors in future research would make the study more rigorous. Lastly, although our study provides great insights into "SRNI" SMEs, other companies, such as those with high capital turnover needs, trade-oriented enterprises, and those facing high market uncertainties, also exhibit significant demand for supply chain finance. Therefore, extending empirical research to these enterprises may yield greater contributions.

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