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Supply-Chain Finance and Investment Efficiency: The Perspective of Sustainable Development

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Abstract: Recent debates regarding supply-chain finance have separated financial attributes from supply-chain attributes, ignoring their unity and the utilization efficiency of funds after financing. Can supply-chain finance affect corporate investment efficiency? There is still insufficient research in existing studies. In this paper, multiple regression analysis is used on 9757 listed companies in China for the period 2010–2020, to empirically test the impact of supply-chain finance on investment efficiency by integrating financial and supply-chain attributes of supply-chain finance, and we further analyze its mechanism. The results show that supply-chain finance can alleviate corporate under-investment and inhibit over-investment. The relationship is stronger for nonstate-owned corporations and is stronger when corporations operate in a superior information environment. Further, financial constraint plays an intermediary role between supply-chain finance and under-investment, while corporate social responsibility plays an intermediary role between supply-chain finance and over-investment. This study enriches the relevant research on the economic consequences of supply-chain finance, and provides new evidence for how supply-chain finance can promote the high-quality development of the real economy.

Keywords: supply-chain finance; investment efficiency; corporate social responsibility; financial constraint

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1. Introduction

In 2021, the Government Work Report proposed an "innovative supply chain finance service model" and "the 14th Five-Year Plan for the National Economic and Social Development of the People's Republic of China and the Outline of Vision and Objectives for 2035", proposed to "promote the innovative development of supply-chain finance". In recent years, The State Council, the People's Bank of China, and the China Banking and Insurance Regulatory Commission have successively issued a series of policies related to promoting the development of supply-chain finance. The 2022 Government Work Report further proposed that participants should "strive to create a good financing situation and further promote the financing problems of the real economy, especially small and medium-sized enterprises". Supply-chain finance helps enterprises, especially small and medium-sized enterprises, to solve the difficulty and high cost of corporate financing.

Supply-chain finance is a lower-cost and higher-efficiency financial model, which is based on the real transactions between core corporations and upstream/downstream corporations. It uses the credit of core corporations to eliminate information asymmetry between information flow, capital flow, and business flow in the supply chain, which can

reduce bank credit risk and alleviate financial constraint of upstream and downstream corporations. Compared with traditional financial services, supply-chain finance has obvious advantages. On the one hand, it provides a new financial channel for upstream and downstream corporations, injects funds into corporations that lack guarantees and mortgages or possess a low credit rating and anti-risk ability, improves the traditional capital loan limit, and resolves the financial difficulties of upstream and downstream corporations. On the other hand, supply-chain finance provides practical financial services for banks, which can help them to connect with individual companies and the whole industry chain. Timely and comprehensive information can reduce the bank's credit risk. In a word, the purpose of supply-chain finance is to optimize the movement of funds among organizations. The ultimate goal is to make the cash flow consistent with the product flow and information flow in the supply chain, and improve the management efficiency of cash flow [1]. After the corporation obtains funds, whether it will use the funds reasonably (investment efficiency) or not is an important and interesting topic.

Under the framework of neoclassicism, the marginal value of investment projects is the only driving force for capital investment decisions. When the marginal income of investment is equal to the marginal cost, the investment level is the best [2]. Financial constraint and agency problems caused by information asymmetry reduce market efficiency, resulting in investment deviation from the optimal level, called over- or under-investment; both represent inefficient investment, which will be affected by financial activities and is directly related to corporate financial constraint. When corporations face serious financial constraint, it will cause insufficient investment [3]. Supply-chain finance as an innovative financial model that can effectively alleviate the financial constraint of enterprises [4]. Therefore, whether supply-chain finance can alleviate the under-investment of enterprises is an important topic. When corporate financial constraint is eased, corporations can obtain more financial support, possibly leading to supply-chain finance promoting over-investment of enterprises. This study attempts to address the following questions: (1) Can supply-chain finance affect corporate investment efficiency (over- and under-investment)? (2) Do the nature of property rights and the information environment affect the relationship between supply-chain finance and corporate investment efficiency? (3) What is the mechanism by which supply-chain finance affects corporate investment efficiency?

The contributions of this paper are mainly reflected in the following aspects: firstly, it enriches the research literature on the economic consequences of supply-chain finance. Although much research has been conducted on supply-chain finance from the financial perspective [5,6] and supply-chain perspective [1], focusing on its role as an important part of financial decision making, few studies have focused on the impact of supply-chain finance on corporate financial behavior, and empirical research on this matter is lacking [7]. From the perspective of investment efficiency, this paper provides empirical evidence that supply-chain finance affects corporate financial decisions. Secondly, this paper presents a novel concept for the research of sustainable supply-chain management. Due to the spread of COVID-19 and the impact of anti-globalization, the supply-chain disruption of enterprises was aggravated. How to incorporate the impact of unexpected factors into the research scope of sustainable supply-chain management has become an important research topic, which can improve the ability to cope with uncertainty. Thirdly, most studies focus on financial attributes or supply-chain attributes, but to some extent, they have separated the unity of these financial and supply-chain attributes. At the same time, these studies lack a focus on the key participation of core enterprises, especially the relationship between supply-chain finance and investment efficiency. This paper fills the gap.

2. Literature Review and Research Hypothesis

2.1. Literature Review

2.1.1. Supply-Chain Finance

The existing literature mainly studies the concept of supply-chain finance, its function and effect, and how to reduce its risk. Firstly, we examine the concept of supply-chain

finance. From the perspective of financial orientation, it is an innovative financial service mode involving core enterprises, upstream suppliers, downstream dealers, and financial institutions, aiming at resolving the financing problems of supply-chain members. It is a financial resource integrating the financing process of supply-chain entities [8], which can provide financial support for upstream and downstream corporations [9,10]. From the perspective of supply-chain orientation, it highlights the importance of a working capital optimization system, e.g., inventory. The core foundation of supply-chain finance is the industrial supply chain, which can help supply-chain participants optimize industrial capital, consolidate the industrial supply chain [11], and optimize industrial structure and cash flow in the supply chain [12]. Secondly, we examine the function and effect of supply-chain finance. It can improve the operating efficiency of capital and cope with a credit crunch during an economic recession [13]. In addition, it can reduce the credit transaction cost of small- and medium-sized corporations, optimize capital, reduce default risk, and improve the efficiency of the supply chain [14]. From the perspective of financial constraint, it can build a bridge between corporations and banks, reducing the risk of imbalance between capital supply and demand [15], which can ease financial constraint [16–18] and improve the financial performance of core enterprises [11,17,19]. In addition, core enterprises carrying out supply-chain finance will influence their cash holdings [20], innovation [4], capital structure adjustment [21], digital transformation [22], and financial performance [11].

Some studies have researched the value-creation function of supply-chain finance, which can optimize financing and integrate the financing process of customers, suppliers, and service providers in order to improve the value of all participating companies [8]. Supply-chain finance can improve the value of suppliers, buyers, and FLS and create a win–win situation, which has value-creation function [4,20,23]. Finally, how to reduce the financial risk of the supply chain is an important research topic. Enterprises usually use supply-chain structure shaping [24], large external data sets [25], and network governance of e-commerce bank platforms [26] to reduce supply-chain risk.

After reviewing the literature, we find that most studies are based on the financial attributes or supply-chain attributes of supply-chain finance, regarding it as a short-term financial solution. This approach, to some extent, separates the organic unity of supply-chain finance's financial attributes and supply-chain attributes. In addition, this approach lacks a focus on the key participation of core enterprises, especially the relationship between supply-chain finance and enterprise investment efficiency, which has not received due attention. On the other hand, existing research focuses on financial support of supply-chain finance. In fact, investment efficiency, reasonably assessing the efficiency of fund utilization, is a more noteworthy topic after obtaining financial support.

2.1.2. Investment Efficiency

Investment decisions are considered to be important factors affecting future development of enterprises. However, the capital market is not perfect, which will reduce effectiveness owing to the "noise" and will lead corporations to make irrational investment decisions, affecting investment efficiency. The reduction of investment efficiency will not only hinder the development of corporations and damage the interests of shareholders, but also lead to the waste of social resources and reduce the allocation efficiency of the capital market. Scholars have carried out a great amount of research on investment efficiency, which mainly includes external governance and internal governance.

On the one hand, macroeconomic policies [27], the level of the rule of law [10], the level of financial market development [28], and economic policy uncertainty [29] are external governance factors that affect investment efficiency. For example, Zhang et al. (2017) tested how industrial policy affected investment efficiency using a DID model, and found that it can reduce enterprise investment efficiency significantly [27]. Mclean et al. (2012) and Li et al. (2015) showed that the development level of financial marketization and legislation improved corporate investment efficiency [28,29]. On the other hand, internal governance mainly focuses on corporate financial characteristics [30], shareholder governance [20],

board governance [31], and compensation incentives [32]. Chen et al. (2011) found that the quality of financial reporting significantly enhanced investment efficiency [30]. Pan et al. (2020) investigated the impact of chain shareholders on enterprise investment behavior and found that the impact of chain shareholders on enterprise investment efficiency is mainly reflected in "competition collusion", leading to insufficient investment in enterprises in the same industry [20]. Shin et al. (2020) studied the role of female directors in board governance and found that the degree of conservatism and prudence of female directors could reduce excessive investment [31]. Lu et al. (2017) found that salary incentives could improve investment efficiency [32]. In addition, with the development of the capital market, scholars have further explored the impact that executives themselves and their behavior may have on investment efficiency. For example, Chen and Wang (2020) found a nonlinear "U" relationship between CEO discretion and investment efficiency [33].

In summary, the existing literature on investment efficiency only addresses the influencing factors, but there is no literature on the impact of supply-chain finance on investment efficiency. From the perspective of supply-chain finance, this paper attempts to study its impact on corporate investment efficiency.

2.2. Research Hypothesis

2.2.1. Supply-Chain Finance and Under-Investment

Supply-chain finance is an emerging financial practice aimed at meeting the needs of supply-chain enterprises. It can affect financial needs in two aspects, detailed below, and subsequently affect the under-investment caused by the lack of funds.

Firstly, it generally improves the external financing ability of enterprises and provides financial support for enterprises from the perspective of the financial attributes [4]. Supply-chain finance can revitalize current assets, and then resolve the problem of a lack of collateral. There are three modes of supply-chain finance: inventory mortgage mode, accounts receivable, and prepayment mode [34,35]. In the inventory mortgage mode, supply-chain enterprises utilize their own movable property as collateral and rely on the supervision of core enterprises to borrow from financial institutions. At the same time, core enterprises repay the loan or buy back the collateral when the borrowing enterprise defaults. In the accounts-receivable model, the upstream suppliers obtain the accounts receivable of the core enterprises as the repayment source, sell goods on credit to the core enterprises, obtain financing with the credit of the core enterprise as the guarantee, and the core enterprises pay off when the supplier is unable to repay. In the prepayment mode, the downstream enterprises in the supply chain use the goods repurchased by the core enterprises (the seller) as the guarantee, keep the goods with the seller or the warehouse designated by the financial institution, and pledge the transportation and storage documents to the financial institution. Supply-chain finance has become a "booster" for enterprises aiming to establish good bank–enterprise relationships, while bank-related enterprises rely more on bank resources to reduce their financing constraints [36]. Therefore, supply-chain finance, as a new financing tool, can effectively improve the external financing ability of enterprises, overcome their financial constraint, and alleviate insufficient corporate investment [4].

Secondly, supply-chain finance can alleviate information asymmetry and reduce financial constraint of upstream and downstream enterprises. Under the supply-chain financing mode, financial institutions no longer provide credit to a single enterprise, and treat all supply-chain enterprises as a whole, forming one too many contractual relationships. Core enterprises, supply-chain enterprises, financial institutions, etc., form a long-term strategic alliance [23]. In addition, compared with financial institutions, core enterprises can know the credit status of upstream and downstream enterprises in the supply chain and provide guarantees for them. The credit guarantee of core enterprises eliminates information asymmetry between logistics, information flow, and capital flow of supply-chain enterprises. Therefore, supply-chain finance effectively alleviates financial constraint [16] and resolves capital demand.

In summary, supply-chain finance alleviates the financial constraint of upstream and downstream enterprises and alleviates under-investment caused by financial difficulties. Therefore, we put forward research hypothesis H1:

Hypothesis 1. *Supply-chain finance alleviates corporate under-investment and improves investment efficiency.*

2.2.2. Supply-Chain Finance and Over-Investment

Under the supply-chain financing model, banks and other financial institutions regard the entire supply chain as a whole, and they form long-term, multiple, and stable cooperation relationships [37]. As a long-term strategic alliance, in order to obtain long-term interests, all parties will implement effective supervision of all parties, which can improve the efficiency of the supply chain and ensure the stable development of the supply chain [7,14]. The contracting parties in the supply chain supervise each other, so that the transaction and capital flow can better describe the real operation of the enterprise and increase the visibility of capital management. Under the supply-chain financing mode, core enterprises have a better understanding of the credit status of upstream and downstream enterprises and provide guarantees for them. Therefore, in order to obtain guarantees, supply-chain enterprises pay more attention to corporate social responsibility, especially supply-chain responsibility [38,39]. Corporate social responsibility has met the different visions of all stakeholders and mobilized their enthusiasm. Therefore, responsible supply-chain members supervise each other, monitor the excessive investment behavior of supply-chain members, and improve corporate investment efficiency [40]. Accordingly, this study proposes research hypothesis H2:

Hypothesis 2. *Supply-chain finance inhibits corporate over-investment and improves investment efficiency.*

3. Research Design

3.1. Samples and Data

This paper takes the data of China's Shanghai and Shenzhen A-share listed companies from 2010 to 2020 as the sample source. Other data were obtained from the China Stock Market and Accounting Research Database. To ensure data quality, we excluded financial, ST-listed, and listed companies with missing financial data. Therefore, 9757 final samples were obtained.

3.2. Variable Definitions

3.2.1. Investment Efficiency

Dependent variables: following Richardson (2006) [41], investment efficiency is measured by investment model. If the residual error is greater than 0, it indicates that the enterprise has over-investment. The larger the residual error is, the greater is the degree of over-investment. If the residual error is less than 0, it means that the enterprise is under-invested. The smaller the residual error is, the greater is the degree of under-investment.

$$Invest_{it} = \beta_0 + \beta_1 Growth_{it-1} + \beta_2 Lev_{it-1} + \beta_3 Cash_{it-1} + \beta_4 Age_{it-1} + \beta_5 \mathrm{Size}_{it-1} + \beta_6 Return_{it-1} + \beta_7 Invest_{it-1} + \sum Year + \sum Industry + \varepsilon_{it} \quad (1)$$

In model (1), *Invest* represents the total new investment in year t, which is equal to (expenditure on fixed assets, intangible assets, and other long-term assets + net cash paid by subsidiaries and other business units—net cash received from the disposal of fixed assets, intangible assets, and other long-term assets—net cash received from the disposal of subsidiaries and other business units—depreciation of fixed assets, depletion of oil and gas assets, and depreciation of productive biological assets-amortization of intangible

assets—amortization of long-term unamortized expenses)/total assets; $Growth_{t-1}$, Lev_{t-1}, $Cash_{t-1}$, Age_{t-1}, $Size_{t-1}$, $Return_{t-1}$, and $Invest_{t-1}$ represent the company's growth, leverage level, cash-holding level, listing age, asset size, stock return, and investment level in year $t-1$, respectively.

Following Richardson (2006), we use the residual of model (1) to measure investment efficiency. If the residual is greater than 0, its value represents over-investment, which is expressed as *OverINV*; the higher the value, the higher the degree of over-investment. If the residual is less than 0, its value represents under-investment. Its absolute value was obtained and expressed using *UnderINV*.

3.2.2. Supply-Chain Finance

Following Yao et al. (2017) [42], we use short-term borrowing, due to the short term of accounts-receivable mortgage financing and inventory mortgage financing. The prepayment financing model mainly adopts a bill of exchange, which is represented by a bill-payable account. The ratio of the sum of short-term loans and notes payable to the total assets of the enterprise at the end of the year is used as the proxy variable of supply-chain finance.

3.2.3. Control Variables

We controlled several variables that affect corporate over-investment and under-investment [20]. Firm characteristic variables include: (1) firm size (Size); (2) asset:liability ratio (Lev); (3) total net asset interest rate (ROA); (4) the ratio of fixed assets (PPE), which is equal to the noncurrent assets at the end of the period divided by the total assets; (5) cash ratio (Cash), which is equal to cash and cash equivalents divided by total assets; (6) investment opportunity (Q), which is equal to market value divided by total assets; (7) enterprise growth (Growth), which is equal to the growth rate of operating revenue; (8) equity concentration (Top1), which is equal to the shareholding ratio of the company's largest shareholder; (8) board size (Board), which is equal to the natural logarithm of the number of directors; (9) independence (Independ), which is equal to the number of independent directors divided by the number of directors; (10) two in one (Dual); when the positions of chairman and general manager are concurrently held, it is equal to one; otherwise, it equals zero; (11) executive compensation level (Salary), which is equal to the natural logarithm of the total compensation of the top three executives.

3.3. Empirical Model

To test the impact of supply-chain finance on corporate investment efficiency, this paper constructs the following model:

$$INV(OverINV/UnderINV)it = \alpha_0 + \alpha_1 * SCF_{it-1} + \sum \alpha_i * Control_{it-1} + \sum Year + \sum Industry + \varepsilon_{it} \quad (2)$$

INV represents corporate investment efficiency, including over-investment and under investment. *OverINV* represents corporate over-investment, *UnderINV* represents corporate under-investment. *Control* represents control variables.

4. Empirical Results

4.1. Descriptive Statistics

Table 1 presents descriptive statistics. The mean value of investment efficiency (INV) is 0.036 and the median is 0.023; the mean value is greater than the median, indicating that the data contain a considerable degree of skewness to the right. The mean value of supply-chain finance (SCF) is 0.135, and the standard deviation is 0.124, indicating large differences in supply-chain financing among corporations. The mean of firm size (Size) equals 22.210, and the standard deviation is 1.337, indicating large differences in size among corporations. The other control variables are within a reasonable range.

Table 1. Descriptive statistics of main variables.

Variables	N	Mean	Median	Std. Dev	Min	Max
INV	9757	0.036	0.023	0.052	0	0.964
Over INV	3896	0.046	0.023	0.073	0	0.964
Under INV	5861	0.030	0.022	0.028	0	0.269
SCF	9757	0.135	0.107	0.124	0	1.119
Size	9757	22.210	22.650	1.337	15.423	28.513
ROA	9757	0.037	0.034	0.056	−0.216	0.195
Lev	9757	0.452	0.450	0.209	0.057	0.934
PPE	9757	0.448	0.435	0.298	0.042	0.914
Cash	9757	0.154	0.161	0.117	0.016	0.579
Growth	9757	0.188	0.163	0.453	−0.559	3.004
Q	9757	2.482	1.930	1.743	0.877	10.850
Top1	9757	0.351	0.333	0.150	0.085	0.750
Board	9757	2.351	2.197	0.201	1.609	2.70
Independ	9757	0.373	0.333	0.053	0.333	0.571
Dual	9757	0.228	0	0.420	0	1
Salary	9757	13.260	14.250	0.718	12.450	16.210

4.2. Regression Analysis

Table 2 represents the multiple regression results of supply-chain finance and investment efficiency. Column (1) represents the regression results without control variables. The coefficient of supply-chain finance (SCF) is significant (coefficient = −0.0031 [t = −3.29]), indicating a significant negative relationship between supply-chain finance (SCF) and over-investment (Over INV). In Column (2), after adding control variables, the negative correlation remains unchanged, which indicates that supply-chain finance can inhibit corporate excessive investment. Thus, Hypothesis 2 is strongly supported. In Columns (3) and (4), there is a negative relationship between supply-chain finance (SCF) and under-investment (Under INV), which indicates that supply-chain finance can alleviate under-investment of enterprises and improves investment efficiency. These conclusions strongly support Hypothesis 1.

Table 2. Regression results of supply-chain finance and investment efficiency.

Variables	Over INV		Under INV	
	(1)	(2)	(3)	(4)
SCF	−0.0031 *** (−3.29)	−0.0600 *** (−2.64)	−0.0101 *** (−6.62)	−0.0060 *** (−2.97)
Size		0.027 *** (4.45)		0.003 ** (2.09)
Lev		0.055 ** (2.13)		0.007 (1.08)
ROA		0.2035 *** (3.36)		0.0715 *** (5.34)
PPE		0.0102 (1.05)		0.0103 *** (6.11)
Cash		0.0176 *** (3.97)		−0.0128 ** (−2.47)
Growth		0.0651 *** (14.25)		0.0049 *** (2.84)
Q		0.1607 *** (5.62)		0.1036 *** (9.45)

Table 2. *Cont.*

Variables	Over INV		Under INV	
	(1)	(2)	(3)	(4)
Top1		−0.0112 (−1.35)		−0.0025 (−0.66)
Board		−0.0219 *** (−3.56)		−0.0019 (−0.66)
Independ		−0.0298 (−1.33)		0.0155 (1.37)
Dual		0.0079 *** (3.17)		−0.0039 *** (−3.55)
Salary		0.0012 (0.61)		−0.0021 ** (−2.27)
Constant		−0.3823 *** (−3.89)		0.5693 *** (3.96)
Year	YES	YES	YES	YES
Industry	YES	YES	YES	YES
N	3896	3896	5861	5861
Adj.R2	0.0316	0.202	0.317	0.522

Note: *** and ** indicate significance level of 1% and 5%respectively. Numbers in parentheses indicate *t*-values.

4.3. Robustness Test

4.3.1. Changing the Time Window

The period for the above empirical results is from 2010 to 2020. We extend the time window to 2000 to 2020 for the robustness test. The results are shown in Table 3. Columns (1) and (2) are the regression results of extending the time window. In Column (1), the relationship between supply-chain finance and under-investment (Under INV) is significantly negative. In Column (2), the negative relationship between them is still verified. China's supply-chain finance policies have been promulgated since 2016. In order to eliminate the interference of other macroeconomic factors, we shorten the time window to test the robustness. Columns (3) and (4) are the regression results of shortening the time window. Retaining the samples from 2016 and later, the regression results of supply-chain finance and corporate investment efficiency are shown in Table 3. In Columns (3) and (4), the negative relationship between them is also still verified. From the regression results of Columns (1) and (3), it can be seen that supply-chain finance can inhibit excessive corporate investment. Columns (2) and (4) indicate that supply-chain finance can alleviate corporate under-investment and improve investment efficiency.

Table 3. Regression results of supply-chain finance and investment efficiency after changing the time window.

Variables	Extending the Time Window		Shortening the Time Window	
	(1) Over INV	(2) Under INV	(3) Over INV	(4) Under INV
SCF	−0.059 *** (−2.92)	−0.004 ** (−1.98)	−0.058 * (−1.95)	−0.006 *** (−2.66)
Size	−0.000 (−0.08)	−0.001 (−0.65)	0.020 (1.38)	0.012 *** (3.69)
Lev	0.054 *** (2.58)	0.002 (0.28)	0.082 (1.61)	−0.006 (−0.68)
ROA	0.139 *** (3.66)	0.038 ** (2.45)	0.168 *** (2.61)	0.047 *** (3.75)

Table 3. *Cont.*

Variables	Extending the Time Window (1) Over INV	(2) Under INV	Shortening the Time Window (3) Over INV	(4) Under INV
PPE	0.006 ***	0.004 ***	−0.004	0.004 ***
	(2.80)	(4.58)	(−1.08)	(5.74)
Cash	0.0704 ***	0.0593 ***	0.0148 *	0.0203 **
	(3.69)	(3.11)	(1.81)	(2.46)
Growth	0.0464 ***	0.0463 ***	0.0037 **	0.0040 **
	(9.56)	(9.54)	(2.22)	(2.40)
Q	0.0068 ***	0.0062 ***	0.0034 ***	0.0033 ***
	(4.25)	(3.88)	(8.71)	(8.17)
Top1	0.0286	0.0122	0.0046	0.0177
	(1.32)	(0.56)	(0.37)	(1.41)
Board	−0.0087	−0.0151	−0.0061	−0.0023
	(−0.72)	(−1.27)	(−1.01)	(−0.38)
Independ	−0.0549	−0.0559	0.0111	0.0137
	(−1.56)	(−1.59)	(0.64)	(0.79)
Dual	0.0053	0.0044	0.0002	0.0002
	(1.17)	(1.00)	(0.13)	(0.10)
Salary	−0.0130 ***	−0.0091 **	−0.0000	−0.0045 **
	(−3.18)	(−2.12)	(−0.01)	(−2.43)
Constant	0.084	0.056 **	−0.008	−0.111 *
	(1.25)	(2.30)	(−0.03)	(−1.71)
Year	YES	YES	YES	YES
Industry	YES	YES	YES	YES
N	5899	7862	2196	3962
Adj.R2	0.0423	0.0373	0.0683	0.1190

Note: ***, **, and * indicate significance level of 1%, 5%, and 10%, respectively. Numbers in parentheses indicate *t*-values.

4.3.2. Redefining Variable

In this test, we replace the measurement of supply-chain finance (SCF). According to Guo and Gu (2022) [43], the sum of short-term loans and notes payable is used as an indicator to measure the development of supply-chain finance. The regression results are shown in Table 4. The sign and significance of the regression coefficient have not changed significantly, and the result is robust.

Table 4. Regression results of supply-chain finance and investment efficiency after redefining variable.

Variables	(1) Over INV	(2) Under INV
SCF	−0.285 **	−0.026 **
	(−2.04)	(−1.99)
Size	0.000	−0.001 ***
	(0.20)	(−3.04)
Lev	0.008	−0.007 ***
	(0.99)	(−3.02)
ROA	0.118 ***	0.024 ***
	(3.98)	(3.22)
PPE	0.001	0.003 ***
	(0.80)	(10.40)

Table 4. *Cont.*

Variables	(1) Over INV	(2) Under INV
Cash	0.0528 ***	−0.0143 ***
	(4.44)	(−2.77)
Growth	0.0642 ***	0.0051 ***
	(13.95)	(3.02)
Q	0.0060 ***	0.0037 ***
	(5.17)	(9.70)
Top1	−0.0180 **	−0.0001
	(−2.19)	(−0.03)
Board	−0.0207 ***	−0.0014
	(−3.23)	(−0.48)
Independ	−0.0327	0.0178
	(−1.48)	(1.58)
Constant	0.0183 ***	0.0371 ***
	(2.93)	(8.99)
Year	YES	YES
Industry	YES	YES
N	3 896	5 861
Adj.R2	0.0213	0.0730

Note: ***and ** indicate significance level of 1% and 5%, respectively. Numbers in parentheses represent *t*-values.

4.3.3. Endogenous Test

Considering that there is no reverse causal relationship between supply-chain finance and investment efficiency, to some extent, the endogenous problem is avoided. Considering that the result may face endogenous problems due to some unobservable factors, this study uses the fixed-effect model to test the regression result. Firstly, we use the Hausman test, which can determine whether a fixed-effect model or random-effect model should be utilized to resolve the endogenous problem caused by missing variables. The result shows that the *p*-value is 0.0000, so the random-effect model is rejected, and the fixed-effect model is selected for the test. The regression result is shown in Table 5, which indicates that the regression result is robust after controlling for the bias of missing variables.

Table 5. Regression results of supply-chain finance and investment efficiency after endogenous test.

Variables	(1) Over INV	(2) Under INV
SCF	−0.0161 ***	−0.026 **
	(−5.12)	(−3.41)
Size	0.0097 ***	−0.0252 ***
	(2.67)	(−10.30)
Lev	0.0674 ***	0.0388 ***
	(3.59)	(5.46)
ROA	0.0820 **	0.0837 ***
	(2.02)	(6.17)
PPE	0.1521 ***	−0.0143 *
	(8.03)	(−1.73)
Cash	0.0704 ***	0.0203 **
	(3.69)	(2.46)
Growth	0.0464 ***	0.0040 **
	(9.56)	(2.40)

Table 5. *Cont.*

Variables	(1) Over INV	(2) Under INV
Q	0.0068 ***	0.0033 ***
	(4.25)	(8.17)
Top1	0.0286	0.0177
	(1.32)	(1.41)
Board	−0.0087	−0.0023
	(−0.72)	(−0.38)
Independ	−0.0549	0.0137
	(−1.56)	(0.79)
Dual	0.0053	0.0002
	(1.17)	(0.10)
Salary	−0.0130 ***	−0.0045 **
	(−3.18)	(−2.43)
Constant	0.0183 ***	0.0371 ***
	(2.93)	(8.99)
Year	YES	YES
Industry	YES	YES
N	3 896	5 861
Adj.R2	0.0213	0.0730

Note: ***, **, and * indicate significance level of 1%, 5%, and 10%, respectively. Numbers in parentheses represent *t*-values.

5. Further Analysis

5.1. Cross-Sectional Heterogeneity Regression Analysis

5.1.1. Heterogeneity Analysis of Property Rights

China's financial system is dominated by state-owned banks, which often adopt loose pre-loan review and post-loan supervision for state-owned enterprises. In other words, the "natural" blood relationship between state-owned enterprises and the government undoubtedly provides an implicit guarantee for state-owned enterprises [44]. However, it is difficult for nonstate-owned enterprises to obtain credit support; they often face strong financial constraint, which usually affects their investment behavior.

We set the dummy variable SOE. When the enterprise is a nonstate-owned enterprise, the value of SOE is one, otherwise it is zero. In Column (1) of Table 6, the multiplicative term between supply-chain finance and property rights (SCF × SOE) is significantly positive at the 10% level, indicating that compared with state-owned enterprises, supply-chain finance has a clearer mitigation effect on nonstate-owned enterprises. In Column (2), the dependent variable is under-investment and the multiplicative term (SCF × SOE) is significantly positive at the 1% level, indicating that compared with state-owned enterprises, supply-chain finance plays a clearer role in alleviating the insufficient investment of nonstate-owned enterprises.

Table 6. Cross-sectional heterogeneity analysis between supply-chain finance and investment efficiency.

Variables	(1) Over INV	(2) Under INV	(3) Over INV	(4) Under INV
SCF	−0.0133 *	−0.0384 ***	−0.0168 ***	−0.0169 ***
	(−1.83)	(−12.89)	(5.14)	(−12.97)
SOE	−0.0201 ***	0.0315		
	(−6.96)	(1.30)		

Table 6. *Cont.*

Variables	(1) Over INV	(2) Under INV	(3) Over INV	(4) Under INV
SCF × SOE	0.0136 *	0.0141 ***		
	(1.89)	(4.17)		
Audit			0.0126	0.0009
			(0.56)	(0.26)
SCF × Audit			0.0092 *	0.0131 **
			(1.86)	(1.99)
Size	0.0114 ***	−0.0268 ***	0.0096 ***	−0.0256 ***
	(5.35)	(−3.39)	(6.34)	(−3.01)
ROA	−0.0916 ***	0.0345 ***	−0.0874 ***	0.0338 ***
	(−2.97)	(3.22)	(−2.84)	(3.15)
Lev	0.0176 ***	0.0661 ***	0.0631 **	0.0659 ***
	(2.71)	(12.77)	(2.28)	(12.70)
PPE	0.1326 ***	0.0396 ***	0.1126 ***	0.0617 ***
	(14.42)	(4.27)	(10.29)	(3.31)
Cash	0.0556 ***	−0.0127 **	0.0474 ***	−0.0127 **
	(4.65)	(−2.26)	(3.97)	(−2.46)
Growth	0.0633 ***	0.0138 ***	0.1651 ***	0.0049 **
	(13.99)	(2.83)	(14.27)	(2.85)
Q	0.0066 ***	0.0036 ***	0.0067 ***	0.0036 ***
	(5.54)	(9.48)	(5.54)	(9.38)
Top1	−0.0048	−0.0031	−0.0312	−0.0026
	(−0.57)	(−0.79)	(−1.34)	(−0.68)
Board	−0.0157 **	−0.0126	−0.0225 ***	−0.0920
	(−2.47)	(−0.79)	(−3.46)	(−0.65)
Independ	−0.0196	0.0156	−0.0291	0.0134
	(−0.87)	(1.38)	(−1.30)	(1.36)
Dual	0.0034 *	−0.0137 ***	0.0078 ***	−0.0039 ***
	(1.73)	(−3.13)	(3.14)	(−3.56)
Salary	0.0008	−0.0062 **	0.1015	−0.1021 **
	(0.42)	(−2.40)	(0.75)	(−2.30)
Constant	−0.1229 ***	0.3738 ***	−0.1818 ***	0.1698 ***
	(−5.87)	(30.54)	(−4.75)	(30.40)
Year	YES	YES	YES	YES
Industry	YES	YES	YES	YES
N	3896	5861	3896	5861
Adj.R2	0.229	0.526	0.216	0.529

Note: ***, **, and * indicate significance level of 1%, 5%, and 10%, respectively. Numbers in parentheses represent *t*-values.

5.1.2. Heterogeneity Analysis of Information Environment

Information environment is an important factor affecting the investment behavior of enterprises. For example, Zhang and Lv (2009) found that information asymmetry can be reduced to information disclosure, which can restrain excessive investment and under-investment behavior [45]. Therefore, it is necessary to test the impact of the information environment on the relationship between supply-chain finance and investment efficiency. Following Zhang et al. (2012), we used external audit quality to measure the information environment; audit quality is defined by whether or not the company is audited by four accounting firms, setting the virtual audit variable [46]. When the enterprise is audited by four accounting firms, the audit value is one; otherwise, it is set to zero. In Table 6, Column

(3), the multiplicative term (SCF × Audit) of supply chain finance and the information environment is significantly negative, at 10%, indicating that the better the information environment, the more that supply-chain finance can alleviate over-investment. In Column (4), the multiplicative term (SCF × Audit) is significantly positive, indicating that the better the information environment, the more that supply-chain finance can alleviate insufficient investment.

5.2. Intermediary Effect Test

5.2.1. Supply-Chain Finance, Corporate Social Responsibility, and Over-Investment

In the supply-chain financing model, financial institutions no longer extend credit to a single enterprise, but treat all supply-chain enterprises as a whole, forming a one-to-many contractual relationship. In other words, supply-chain members are a community of interests. Core enterprises, supply-chain enterprises, financial institutions, logistics, etc., form a long-term strategic alliance in the same relationship. In addition, compared with financial institutions, core enterprises have a better understanding of the credit status of upstream and downstream enterprises and provide guarantees for them. Therefore, in order to obtain guarantees, supply-chain enterprises pay more attention to corporate social responsibility, especially supply-chain responsibility [38]. Corporate social responsibility has met the different visions of all stakeholders, mobilized their enthusiasm, and promoted the effective improvement of corporate governance. Therefore, it can prevent over-investment behavior [40]. Therefore, corporate social responsibility plays an intermediary role between supply-chain finance and over-investment.

Following Wen et al. (2004) [47], this study uses the stepwise regression method to test the intermediary effect of corporate social responsibility between supply-chain finance and investment efficiency. The regression results are shown in Table 7. In Columns (1), (2), and (3), the coefficient of supply-chain finance (*SCF*) is significant, at 1%, indicating that supply-chain finance can significantly increase corporate social responsibility. The regression coefficient between corporate social responsibility and over-investment (over) is significant, at 1%, indicating that corporate social responsibility plays an intermediary effect between supply-chain finance and over-investment.

Table 7. Intermediary effect test between supply-chain finance and investment efficiency.

Variables	**Over INV**			**Under INV**		
	(1)	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**
	Over	**CSR**	**Over**	**Under**	**SA**	**Under**
SCF	−0.0163 ***	0.0130 ***	−0.0068 ***	−0.0168 ***	0.0296 ***	−0.0159 ***
	(−4.79)	(7.99)	(3.69)	(−11.95)	(−6.29)	(−8.91)
CSR			−0.0368 ***			
			(−6.99)			
SA						−0.0165 **
						(−5.80)
Size	0.0189 ***	0.0289 ***	0.0075 ***	−0.0257 ***	−0.0502 ***	−0.0263 ***
	(5.48)	(4.31)	(3.87)	(−31.57)	(−5.00)	(−31.99)
ROA	−0.0598 ***	−0.7061 ***	−0.0652 **	0.0339 ***	−0.2860 ***	0.0301 ***
	(−2.91)	(−6.09)	(−2.13)	(3.16)	(−4.45)	(2.81)
Lev	0.0225 **	−0.3175 ***	0.0332 ***	0.0459 ***	−0.2111 ***	0.0431 ***
	(2.21)	(−7.73)	(3.26)	(12.73)	(−7.59)	(11.80)
PPE	0.1301 ***	−0.1267 ***	0.1356 ***	0.0169 ***	−0.1293 ***	0.0331 ***
	(6.25)	(−3.99)	(5.02)	(5.34)	(−4.43)	(3.90)
Cash	0.0376 ***	−0.6493 ***	0.0628 ***	−0.0318 **	−0.1962 ***	−0.0163 ***
	(3.97)	(−2.66)	(2.62)	(−2.67)	(−3.07)	(−2.97)

Table 7. *Cont.*

Variables	Over INV			Under INV		
	(1) Over	(2) CSR	(3) Over	(4) Under	(5) SA	(6) Under
Growth	0.0659 ***	0.0293 ***	0.0612 ***	0.0049 ***	0.0265 ***	0.0051 ***
	(14.25)	(3.89)	(13.95)	(2.84)	(3.11)	(3.02)
Q	0.0168 ***	0.0201 ***	0.0060 ***	0.0036 ***	0.0070 *	0.0037 ***
	(5.62)	(4.63)	(5.17)	(9.45)	(1.85)	(9.70)
Top1	−0.0112	0.1940 ***	−0.0180 **	−0.0025	0.1774 ***	−0.0006
	(−1.35)	(4.67)	(−2.19)	(−0.66)	(5.38)	(−0.03)
Board	−0.0229 ***	−0.0643 *	−0.0267 ***	−0.0069	0.0376	−0.0016
	(−3.53)	(−1.90)	(−3.63)	(−0.64)	(1.34)	(−0.49)
Independ	−0.0298	0.0830	−0.0327	0.0155	0.1728 **	0.0178
	(−1.33)	(0.76)	(−1.48)	(1.37)	(2.00)	(1.58)
Dual	0.0179 ***	0.0960 ***	0.0016 *	−0.0039 ***	0.0635 ***	−0.0031 ***
	(3.17)	(8.45)	(1.82)	(−3.55)	(7.23)	(−2.75)
Salary	0.0062	−0.0241 ***	0.0020	−0.0021 **	−0.0205 ***	−0.0026 **
	(0.61)	(−2.60)	(1.04)	(−2.27)	(−2.77)	(−2.58)
Constant	−0.1123 ***	−1.8166 ***	−0.0694	0.5699 ***	−2.1818 ***	0.5786 ***
	(−4.89)	(−19.35)	(−1.33)	(30.80)	(−9.81)	(29.11)
Year	YES	YES	YES	YES	YES	YES
Industry	YES	YES	YES	YES	YES	YES
N	3896	3896	3896	5861	5861	5861
Adj.R2	0.212	0.216	0.219	0.526	0.329	0.516

Note: ***, **, and * indicate significance level of 1%, 5%, and 10%, respectively. Numbers in parentheses represent *t*-values.

5.2.2. Supply-Chain Finance, Financial Constraint, and Under-Investment

In addition, supply-chain finance can revitalize current assets, thus resolving the lack of collateral and easing financial constraint, which can reduce the financial constraint of upstream and downstream enterprises [48]. Subsequently, whether or not financial constraint plays an intermediary role between supply-chain finance and under-investment is also an important issue.

Following Wen et al. (2004) [47], this study uses the stepwise regression method to test the intermediary effect of financial constraint between supply-chain finance and investment efficiency. The regression results are shown in Table 7. From Columns (4), (5), and (6), it can be seen that supply-chain finance alleviates financial constraint, which plays an intermediary effect between supply-chain finance and under-investment.

6. Conclusions and Implications

Currently, whether and how supply-chain finance can achieve expected economic effects is an important topic. As a new form of the integration of industry and finance, supply-chain finance will not change the nature of finance, the fundamental purpose of which remains matching the demand and supply of funds. However, how to use the funds efficiently is crucial. Therefore, this study examines the relationship between supply-chain finance and corporate investment efficiency. Using data from China between 2010 and 2020, we find that supply-chain finance can alleviate corporate under-investment and inhibit corporate excessive investment. The relationship is stronger for nonstate-owned enterprises and stronger when corporations operate in a superior information environment. Meanwhile, we test the intermediary path by which supply-chain finance affects corporate investment efficiency, and find that financial constraint plays an intermediary role between supply-chain finance and corporate under-investment, while corporate social responsibility plays an intermediary role between supply-chain finance and corporate over-investment.

The results indicate that supply-chain finance achieves the expected effect of serving the real economy, which can improve resource-allocation efficiency.

The major implications are as follows: Firstly, from the perspective of supply-chain finance, we study its impact on investment efficiency, which not only provides a more comprehensive understanding of supply-chain finance on the economic behavior of enterprises and economic consequences, but also provides information regarding the investment and financing behavior of enterprises and further enriches research on investment behavior. Secondly, our study has practical significance. For micro-enterprises, supply-chain finance can alleviate financial constraint of enterprises, which can make enterprises have greater freedom in investment decision making, alleviate corporate under-investment, and inhibit their excessive investment. Therefore, financial institutions and relevant government departments should consider supply-chain finance to provide funds for enterprises with a targeted aim, alleviate corporate under-investment, curb over-investment, and improve the allocation efficiency of the capital market.

This study suffers from limitations that suggest possible avenues for future studies. Firstly, this paper only focuses on the current supply-chain situation in China. Supply-chain finance for Chinese enterprises is very important, especially for private enterprises. Under the special institutional background of China, compared to state-owned enterprises, private enterprises face difficulties obtaining financing. In the future, the research will be expanded to countries around the world and will study the impact of global supply-chain finance on investment efficiency. Secondly, the data for 2021–2023, which was the period of the COVID-19 pandemic, can better demonstrate the impact of the epidemic on the supply chain. However, China's financial statements are generally released in the subsequent year. For example, the financial statements of 2022 have not been published, and the data for 2023 are even less likely to be available.

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