



Supply Chain Finance Instruments and Supply Chain Resilience: Evidence from Tool-Level Classification

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Abstract

This study examines whether different supply chain finance (SCF) instruments have heterogeneous effects on corporate supply chain resilience. Most previous research has treated SCF as a single indicator of practice and used financial proxies, binary indicators or keyword frequency; therefore, the instruments employed by firms have not been systematically identified. We build a text-based measurement system that combines semantic similarity screening, negative-statement identification, supply-chain context constraints and an ERNIE-based classifier. The four categories of SCF instruments are identified from the annual reports of Chinese A-share listed companies between 2010 and 2024: receivables-based, prepayment-based, inventory-based, and comprehensive instruments. SCF as a whole has improved the resilience of the supply chain in the experiment. At the level of the instrument, receivables-based, inventory-based and comprehensive instruments are positively correlated; however, prepayment-based instruments do not show a statistically significant effect. Mechanism experiments have shown that accounts receivable-based financing reduces financing costs, inventory-based financing increases operating cash flow, and all-around financing strengthens supply chain transparency, etc. Different concentrations of the supply chain, digitalisation and regions will also have different effects. Based on the above analysis, the resilience level of SCF varies according to the design of instruments and other factors at the firm level.

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Keywords: supply chain finance; supply chain resilience; financial instruments; text analysis; language models

1. Introduction

Geopolitical risks, natural disasters, and other sources of supply disruption are increasing worldwide. Such a disturbance will spread throughout the network of enterprises and cause other problems for them. Therefore, resilience of a company is no longer just about crisis recovery. It can also absorb shocks, adjust operations under the influence of disruption, and then recover or improve performance after the shock.

Supply chain finance may enhance the above capabilities by coordinating financial flows with product and information flows. SCF is not a traditional loan; it is tied to real transactions and often relies on the credit of a core enterprise, verified orders, accounts receivable, inventory or platform data, etc., rather than just the borrower's individual credit and collateral. Free up liquidity tied up in working capital, reduce information asymmetry, and enhance coordination among buyers, suppliers, logistics providers and financial institutions (Hofmann & Kotzab, 2010; Wuttke *et al.*, 2013) ^[2, 11].

SCF is also not a single device. Receivables financing is the conversion of customer claims into immediate funds; prepayment financing helps downstream buyers obtain future goods; inventory financing uses inventories or warehouse receipts as collateral; and an all-encompassing SCF platform provides multiple financing and information services. The borrowers, asset bases, cash-flow directions, risk control and information needs of these instruments all differ. Treating them all the same may ignore the serious structural problems.

The second problem is Measurement. Financial ratios are seasonal and cyclical; binary indicators cannot differentiate between symbolic disclosure and actual implementation; and keyword counts may reflect the focus of management rather than real application. Given the above shortcomings, this paper introduces a language-model-based measure of instrument-level SCF usage. Only separate the actual implementation from the general discussion or negative statements and require financing terms to appear in the context of a supply-chain transaction.

Using Chinese A-share listed companies from 2010 to 2024, we investigate three problems. Will SCF boost supply chain resilience first? Second, do different SCF instruments produce different effects? Third, by what means and under what circumstances do these effects occur? This study connects the type of instrument, transmission mode and robustness indicators in a single empirical system. It can also provide a more specific plan for text measurement and shows that policy and management recommendations should be different.

2. Theoretical Background and Hypotheses

Supply chain resilience is a system's capacity to operate normally in the face of disturbances, adjust resource allocation according to changes in circumstances, and recover to a normal or even higher level. According to the above capability perspective, resilience has three attributes. Absorptive capacity is the financial and operating buffer available before a shock. Adaptive capacity refers to a change in the procurement-production-inventory-relationship system after a disruption. Recovery capacity refers to the reconstruction of operations, learning, innovation, and extended restructuring.

SCF can cover all three areas. Monetising accounts receivable and inventories increases the company's liquidity cushion to cover purchasing and production expenses during a period of lower revenue. Allocate funds according to the cycle of funds turnover to support supply changes, adjust inventory management policies and release funds. After the disruption, the same liquidity and information-sharing arrangements can finance restocking, repair and network reconstruction. Therefore:

H1: Supply Chain Finance promotes the construction of a resilient supply chain.

However, the results are not the same. Receivables-based instruments enable upstream suppliers to transfer or pledge accounts receivable to obtain cash before the buyer's payment date. Extend the credit quality of the core buyers to small- and medium-sized suppliers, reduce financing costs, and lower the risk of late delivery from financially weak suppliers.

Prepayment-based instruments help the downstream enterprise secure future goods or warehouse space with limited initial capital. They may reduce the risk of price increases and supply shortages, but their direct liquidity effect is less certain because the transaction involves payment for future resources and does not immediately convert existing assets into cash.

Inventory-based instruments convert inventories or warehouse receipts into collateral. It will be very useful for manufacturing and trading companies with a high proportion of equity capital. The released cash will cover operating expenses during a low-demand period or inventory buildup. All-encompassing instruments are generally distributed via

platforms or integrated systems headed by core enterprises and third-party providers. Combine financing channels and connect transaction, logistics, inventory and payment data. The main reasons for the high-resilience are greater openness and coordinated responses in the supply chain.

H2: The Effect of Supply Chain Finance on Supply Chain Resilience Differs by Instrument Type.

Three Mechanisms are proposed. First, SCF can reduce financing costs by using verified transactions and core-firm credit to lower information-screening and collateral costs. Second, increase operating cash flow by accelerating the collection of accounts receivable or funds recovery from inventory. Thirdly, the platform will reinforce the supply chain through standardised and shared transactions, logistics and financial data.

H3: Supply chain finance enhances supply chain resilience by reducing financing costs, increasing operating cash flow, and improving supply chain transparency

3. Research Design

3.1. Sample and data

The samples are listed Chinese companies from the Shanghai and Shenzhen Stock Exchanges between 2010 and 2024. Exclude ST and PT firms and observations with severe missing data. Financial and governance data are obtained from CSMAR; patent and supplementary data from CNRDS; annual-report texts from the official disclosure platform CNINFO. After matching variables, the main regressions have 29,049 firm-year observations.

3.2. Measuring supply chain finance

SCF generally includes receivables-based, prepayment-based, inventory-based, etc., types of instruments. The text-analysis procedure consists of five steps.

First, Seed dictionaries are built from Chinese policy documents and previous research. Typical terms include factoring, receivables pledges, confirmed warehouse financing, future goods rights, warehouse receipt pledges and SCF platforms. Word2Vec-based semantic expansion produces a dictionary of over 200 terms.

Second, representative positive sentences are collected for each instrument, along with negative sentences such as "not yet implemented" or "not involved", and the BGE Chinese embedding model converts sentences into vectors. Retain candidate sentences if their similarity to one instrument category exceeds the specified threshold and their similarity to the negative set is less than the exclusion threshold.

Third, rule-based negation detection is combined with a BERT classifier to exclude statements that mention an instrument but do not actually use it. Fourth, there is a supply-chain context constraint: a financing term is counted only if the same semantic unit also contains transaction-related words such as supplier, customer, order, receivable, payable, core firm, or upstream/downstream. Thus, the ordinary corporate financing will not be classified as SCF.

Fifth, an ERNIE 3.0 classifier is fine-tuned on the screened samples and then applied to classify all annual-report sentences. Instrument intensity is the number of sentences in a particular category divided by the total number of sentences in the annual report. The sum of the four measures is the total SCF intensity. For identification purposes, firm-year observations that are simultaneously employed as instruments are excluded from instrument-specific estimations.

3.3. Measuring resilience and other variables

Supply chain resilience is an all-encompassing index that includes absorption, adaptation and recovery capacities. Assets, earnings fluctuations and inventory turnover rates are measures of absorptive capacity. Adaptive capacity refers to financing constraints, accounts payable and receivable turnover, and customer, supplier and overall supply chain concentration. Recovery capacity refers to invention patents, joint invention applications and ESG performance. The indicators are sorted by the level of robustness they have, and then a stable-period index is constructed.

The regressions control for ownership concentration, ownership imbalance, the largest shareholder's share, board independence, board size, Big Four auditing, employment and audit fees. Firm and year fixed effects are in the main model, and industry effects are also controlled for. Based on the descriptive statistics, receivables-based finance is the most frequently mentioned type with a mean intensity of 0.0573; comprehensive finance is 0.0171; inventory finance is 0.0037; and prepayment finance is 0.0023. The relatively

low average indicates that formal SCF adoption is still limited among many listed companies and has a large development space. The entire model is:

$$\text{Res_it} = \alpha + \beta \text{SCF_it} + \gamma \text{Controls_it} + \text{Firm_i} + \text{Year_t} + \varepsilon_{it}$$

$$\text{Res_it} = \alpha + \beta_1 \text{Receivables_it} + \beta_2 \text{Prepayment_it} + \beta_3 \text{Inventory_it} + \beta_4 \text{Comprehensive_it} + \gamma \text{Controls_it} + \text{Firm_i} + \text{Year_t} + \varepsilon_{it}$$

3.4. Descriptive statistics

Table 1 shows the primary variables. The mean resilience index is -2.4299. The average intensity of receivables-based finance is 0.0573; it is significantly higher than that of prepayment (0.0023), inventory (0.0037) and comprehensive finance (0.0171), and thus the most frequently disclosed SCF instrument in the sample. A large number of zero values also indicate that formal SCF instruments are not widely used by Chinese listed companies.

Table 1: Descriptive Statistics

Variable	Obs.	Mean	SD	Min	Median	Max
Res	29,947	-2.4299	0.395	-3.2372	-2.4938	-0.9806
Receivables	33,398	0.0573	0.119	0.0000	0.0000	0.7100
Prepayment	33,398	0.0023	0.017	0.0000	0.0000	0.2000
Inventory	33,398	0.0037	0.021	0.0000	0.0000	0.2300
Comprehensive	33,398	0.0171	0.066	0.0000	0.0000	0.6700
Herfindahl10	33,378	0.1603	0.114	0.0109	0.1319	0.5880
Balance2	33,376	0.7402	0.611	0.0186	0.5779	2.9617
Top1	33,378	0.3420	0.149	0.0749	0.3207	0.7579
Indep	33,376	0.3759	0.054	0.2857	0.3636	0.6000
Board	33,376	2.1218	0.199	1.6094	2.1972	2.7081
Big4	33,377	0.0556	0.229	0.0000	0.0000	1.0000
Employee2	33,362	7.5176	1.243	4.0604	7.4399	11.1807
AuditFee2	32,788	13.7674	0.668	12.2061	13.6990	16.3571
Cost	31,546	0.0036	0.048	-1.0979	0.0108	0.9466
CFO	26,033	19.1202	1.659	9.7321	19.0673	23.8635
SCT	5,996	1.9954	0.631	0.0000	2.3026	2.3026

R is for the Supply Chain Resilience Index. Cost, CFO and SCT refer to financing cost, operating cash flow and supply chain transparency, respectively

4. Empirical Results

4.1. Baseline findings

Table 2 shows the first regressions. The total SCF has a positive coefficient of 7.859 and is significant at the 1% level. This supports H1, and transaction-based finance enhances a company's resistance to and recovery after disturbances.

Instrument-level results show a deviation. Receivables-based finance has a coefficient of 9.217 and is significant at the 1% level. The largest coefficient, 24.313, also exceeds the 1% significance level for inventory-based financing. Comprehensive finance has a coefficient of 8.432 and is statistically significant at the 5% level. Prepayment-based finance has a negative coefficient, but it is not statistically

significant. H2 is therefore confirmed.

It is also economically reasonable. Receivables and inventory instruments immediately convert illiquid working-capital assets into cash. Inventory financing is expected to have a larger impact because inventories are generally large, relatively illiquid components of assets in manufacturing and trading enterprises. Comprehensive instruments also enhance resilience, but their average effect may be lower due to the immaturity or incomplete integration of the platform. Prepayment arrangements can secure funds, but it is not guaranteed that the money will be available at that time, so there will be no significant average effect.

Table 2: Baseline Regression Results

Variable	(1) Res	(2) Res
SCF	7.859*** (2.218)	
Receivables		9.217*** (2.857)
Prepayment		-7.304 (12.512)
Inventory		24.313*** (9.319)
Comprehensive		8.432** (3.887)
Constant	-3.017*** (0.176)	-3.014*** (0.176)
Controls	Yes	Yes
Year fixed effects	Yes	Yes
Industry fixed effects	Yes	Yes
Observations	29,049	29,049
R-squared	0.710	0.710

Cluster-robust standard errors are shown in parentheses. ** p < 0.05; *** p < 0.01.

4.2. Robustness and endogeneity

Table 3 shows the robustness and endogeneity tests. Some experiments support the first conclusion. Replace the language model indicator with a manually verified dictionary-based index, and it is positively correlated at the 5% level (coefficient = 0.037). After adding province and city fixed effects, the coefficient is 8.471 and significant at the 1% level.

Instrumental variables use the combination of capital intensity and local financial-institution loan balances to

determine how much a firm is substituting conventional loans for SCF. The first-stage coefficient is statistically significant, and the Kleibergen-Paap and Cragg-Donald statistics exceed the weak-instrument threshold. SCF is positive and significant in the second time. A system-GMM specification also yields a positive coefficient of 3.002 at the 5% level. The AR(2) and Hansen tests do not reject the assumption of validity for the model. The above tests indicate that the reasons for this are not due to differences in measurement, regions, omitted variables or reverse causality.

Table 3: Robustness and Endogeneity Tests

Variable	(1) Alternative measure	(2) Additional regional FE	(3) IV first stage: SCF	(4) IV second stage: Res	(5) System GMM: Res
SCF		8.471*** (2.427)		108.711** (42.704)	3.002** (1.261)
SCF1	0.037** (0.018)				
IV1			-0.055*** (0.011)		
L.Res					0.715*** (0.036)
Controls	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes
Industry FE	Yes	Yes	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes	Yes	Yes
Observations	21,939	23,287	26,939	26,939	22,987
K-P rk Wald F				26.90	
Cragg-Donald Wald F				48.83	
Stock-Yogo 10% critical value				16.38	
K-P rk LM				23.80 (p=0.000)	
AR(1) p-value					0.000
AR(2) p-value					0.099
Hansen p-value					0.844

Column (1) is the manually verified dictionary-based indicator SCF1. Column (2) adds province and city fixed effects. Columns (3)-(4) are the instrumental-variable estimates. Column (5) shows the system-GMM estimates. **p < 0.05; *** p < 0.01.

4.3. Mechanisms

Table 4 shows the mechanism tests. Therefore, H3 has been supported, and the significant instruments exhibit different behaviours.

Receivables-based Finance reduces financing costs. The coefficient of the financing-cost regression is -0.806, and it is significant at the 1% level. Verified accounts receivable and essential-buyer credit reduce screening and collateral requirements for suppliers, lowering their funds-raising costs. Lower financing costs increase the available funds for the disruption and reduce the pressure of financing recovery.

Inventory-based Finance increases operating cash flow. It is 87.063 and statistically significant at the 1% level. Pledging inventories or warehouse receipts release cash tied up in stocks to support procurement and production, adjust operating plans, and finance recovery.

Integrated Finance Enhances Supply Chain Transparency. Its coefficient is 21.996 and significantly large at the 5% level. The integrated platform needs to standardise and share transaction, logistics and finance data. Help supply chain participants recognise the risk earlier, coordinate a response, and monitor recovery.

Table 4: Mechanism Test

Variable	(1) Financing cost (Cost)	(2) Operating cash flow (CFO)	(3) Transparency (SCT)
Receivables	-0.806*** (0.305)		
Inventory		87.063*** (31.512)	
Comprehensive			21.996** (10.456)
Constant	-0.063*** (0.020)	10.043*** (0.519)	2.509*** (0.493)
Controls	Yes	Yes	Yes
Year FE	Yes	Yes	Yes
Industry FE	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes
Observations	30,679	25,052	5,335
R-squared	0.424	0.702	0.724

Cluster-robust standard errors are shown in parentheses. ** p < 0.05; *** p < 0.01.

4.4. Heterogeneity

Table 5 shows the heterogeneity results. The Extent of change in the supply chain will differ by region. Receivables finance is relatively common among firms in less concentrated supply chains. A large number of customers are spread out, so the amount of accounts receivable is relatively small. Inventory and comprehensive finance are typical of enterprises with concentrated supply chains, and close, stable relationships can be used to ensure the accuracy of inventory verification and monitoring, as well as platform coordination. Digitalisation has also reduced instrument efficiency. Receivables finance has a stronger effect for firms with lower digitalisation, possibly because it addresses the problems of severe information asymmetry and limited access to traditional credit. Inventory and comprehensive finance are relatively high among the highly digitalised enterprises. These tools need to have real-time inventory data, tracing capabilities and valuations, and system integration; they are

all supported by digital technology.

Receivables, inventory and other current assets are relatively high in Eastern China compared with the other areas. The East generally has more developed financial markets, logistics infrastructure, data systems and professional service networks that support instrument implementation and risk control.

All the heterogeneity tests show that none of the instruments are generally better. Receivables finance is appropriate when a firm needs an alternative to traditional credit and has widely dispersed accounts receivable. Inventory finance will offer better benefits if the inventory is relatively easy to observe and control. Broad-based finance needs both good relationships and digital technology. Therefore, the difference in the estimated coefficients should not be interpreted as an order of products; it may be that the instruments have been applied in different operating environments.

Table 5: Heterogeneity Analysis

Variable	(1) High concentration	(2) Low concentration	(3) High digitalization	(4) Low digitalization	(5) Eastern region	(6) Non-eastern region
Receivables	6.001(3.884)	11.648*** (3.011)	4.608(4.271)	15.294*** (3.681)	8.141** (3.279)	8.789(6.180)
Inventory	42.330*** (15.148)	6.099(10.362)	45.153*** (13.111)	6.415(11.674)	25.535** (10.584)	8.227(21.964)
Comprehensive	17.021*** (5.714)	5.444(4.302)	15.042** (7.234)	3.088(4.680)	14.237*** (3.939)	-14.017(11.409)
Constant	-2.927*** (0.267)	-2.627*** (0.201)	-2.320*** (0.250)	-3.477*** (0.235)	-2.836*** (0.238)	-3.261*** (0.282)
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Industry FE	Yes	Yes	Yes	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes
Observations	13,425	14,976	14,241	14,076	15,860	7,453
R-squared	0.702	0.734	0.693	0.753	0.727	0.721

Notes: The sample is divided at the annual median for supply chain concentration and digitalisation. ** p < 0.05; *** p < 0.01.

5. Discussion and Implications

Based on the above results, SCF should be regarded as a collection of instruments rather than a single financial behaviour. The Type of assets financed and the information architecture for the transaction determine the degree of resilience. Liquidity-oriented instruments are most suitable for releasing cash from existing assets, and platform-based instruments require rich digital and institutional infrastructure.

The research provides two theoretical supports. First, it expands resource-orchestration reasoning to show that access to finance is only one component of resilience construction. The problem is how a financial product affects the availability, timing and visibility of funds. Receivables financing changes the time and cost of liquidity; inventory financing modifies the use of tangible assets; and all forms of financing affect the information environment for joint

operations. Second, the results connect particular mechanisms to particular instruments. Instrument-Mechanism Matching can offer a more testable explanation for the general claim that SCF enhances performance by "optimising financing", and it can also account for why prior studies using aggregate SCF indicators have yielded different effect sizes.

Instrument selection should correspond to the primary cause of a firm's vulnerability. Suppliers who can be paid later will gain more from accounts receivable financing. Firms with large stocks and frequent warehouse operations will be better off under inventory financing. Firms that are members of complex networks may use all-encompassing platforms to spread and coordinate decisions. Prepayment finance should be used sparingly; it does not guarantee the strength of liquidity and resilience automatically.

Banks can develop all-weather risk-assessment and product

design systems. Receivables products need a certain assurance of the underlying transaction and the buyer's obligation. Dynamically monitor inventory products, standardise warehouse receipts and accurately value them. All-encompassing platforms require interoperable data standards and clear governance of data access, verification and responsibility.

Targeted Support Policies will be introduced. The regulator will promote standardised online verification of accounts receivable, digital warehouse facilities and a single window for transaction and logistics data. Support should be based on the features of the company: accounts receivable financing is more suitable for less digitalised enterprises and those with complex supply networks, while inventory and comprehensive financing are more appropriate in environments where digital monitoring and close-knit supply chains are already in place. The regions are not the same; thus, strengthening infrastructure and institutional capacity is required before the advanced SCF model can be applied more broadly outside developed countries.

6. Conclusion

This study develops an instrument-level measure of supply chain finance and examines its association with supply chain resilience among Chinese listed companies from 2010 to 2024. SCF is positively correlated with resilience, but this relationship is not uniform. Receivables-based, inventory-based and comprehensive instruments have improved risk resilience; prepayment-based instruments have shown no significant average effect. These three types of changes are also due to differences in mechanism: lower financing costs, better cash flow and higher transparency. The operation level will be affected by concentration, digitalisation and area.

Thus, the purpose of SCF is to enhance financing and, at the same time, to match a specific financial instrument with a company's assets, information facilities and supply network. This study only examines listed companies' annual reports and therefore fails to uncover information on informal financing and smaller private enterprises. The resilience index also measures broad organizational capacity rather than responses to one identified disruption. Future research may apply the above approach to private enterprises and other countries, add disruption-event data, compare text disclosure with transaction-level records, and investigate whether multiple instruments are used simultaneously rather than being excluded.

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