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The impact of supply chain finance on firm cash holdings: Evidence from China

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ABSTRACT

We establish a link between supply chain finance (SCF) and a firm's cash holdings through a proprietary dataset of listed firms on the Shanghai and Shenzhen Stock Exchanges. Our findings suggest that SCF may significantly improve cash holdings by a core firm, speed up its cash turnover, and enhance its competitiveness. Such impacts are stronger when the firm is of lower efficiency. In addition, a firm with more commercial credit or of state ownership is more likely to become committed to SCF. A close relationship with banks or political connections may further improve the private firm's cash holdings. In the meantime, increased cash holdings at the core firm may lead to enhanced investment efficiency, rather than over-investment, and enhanced firm values. Our findings may have such policy implications that SCF needs to be better supported by the banking sector and the government for China's sustainable economic success.

1. Introduction

Since the Global Financial Crisis (GFC) in 2008, supply chain finance (SCF) has emerged as an efficient means of short-term financing to alleviate a firm's financial constraint (Nienhuis et al., 2013; Ali et al., 2019; Jia et al., 2020). Often with better access to bank loans and enjoying more commercial credit, a core firm in SCF can share its financial resources with other firms in the supply chain or provide guarantees to facilitate small and medium-sized enterprises (SMEs) to borrow bank loans. Given the outstanding lending preference towards state-owned enterprises (SOEs) (Xu and Lin, 2007; Fu et al., 2015; Xu et al., 2015), and the traditional bias against either SMEs or those of private ownership (Allen et al., 2005; He et al., 2019; Li et al., 2020a; Li et al., 2020b; Wu and Xu, 2020), SCF has been growing rapidly in the largest bank-based economy (Lin and Zhang, 2020; Song et al., 2020).

Through SCF, the core firm may effectively support an ecosystem of suppliers, manufacturers, distributors, and customers with better controls of capital, logistics, and information capital flows (Danny et al., 2010). The optimised capital flow within the supply chain may be realised with support from banks (Camerinelli, 2009; Lamoureux and Evans, 2011) and cash flow management can be enhanced when capital and product flows are aligned (Wuttke et al., 2013a). Closely tied to upstream and downstream stakeholders, the core firm may efficiently allocate funds from banks and other creditors to various firms in the supply chain, especially the SMEs, and subsequently improve the competitiveness of the supply chain. To facilitate SCF development, the State Council, the People's...
Bank of China (PBC), China Banking and Insurance Regulatory Commission (CBIRC), China Securities Regulatory Commission (CSRC), Ministry of Finance (MOF), and Ministry of Commerce (MOC), have all intensively issued relevant policies in recent years.  

The literature on SCF has been evolving in two strains. The finance strain commonly defines SCF as a short-term financing solution (Camerinelli, 2009; Lamoureux and Evans, 2011; More and Basu, 2013). As an important financial innovation bridging bank loans and firms in need, SCF may serve the purpose of simultaneous management of a core firm's working capital and that of the supply chain with such a mechanism as reverse factoring (Lekkakos and Serrano, 2016). In addition, SCF may effectively improve capital efficiency during times of a credit crunch (Polak et al., 2012). Through reduced transaction cost and default risks, SCF may optimise efficiency of the supply chain, where SMEs play important roles (Ali et al., 2019). In comparison, the supply chain strain focuses on the optimisation of the ecosystem (Polak et al., 2012; Hofmann and Kotzab, 2010). SCF may contribute to framework design and risk management in particular sectors (Hofmann and Belin, 2011). Integrating the financial needs of suppliers, manufacturers, distributors, and customers, SCF provides an optimal solution (Hofmann, 2014). The integration of material, information, and capital flows, in subsequence, contribute to improved firm performance (Danny et al., 2010). However, there is a growing need for further empirical and theoretical discussions on the core firm with reference to its sector's features, such as its behaviour and performance (Gelsomino et al., 2016). Given the voluntary practice of information disclosure on supply chains in most regulatory regimes, there has been scarce empirical literature on core firms in SCF.

In this study, we examine the impact of SCF on a core firm's cash holdings through a proprietary dataset of listed firms on the Shanghai and Shenzhen Stock Exchanges. Our findings suggest that SCF may significantly improve cash holdings by the core firm, speed up its cash turnover, and enhance its competitiveness. These impacts are stronger when the firm is of lower efficiency. In addition, a firm with more commercial credit or of state ownership is more likely to become committed to SCF. A closer relationship with banks or political connections may further improve the private firm's cash holdings. In the meantime, increased cash holdings at a core firm may lead to enhanced investment efficiency, rather than over-investment, and enhanced firm values. In other words, SCF may play positive roles in improving the firm's efficiency and competitiveness and be meaningful for the development of real economy.

Our study may be meaningful in at least four aspects. First, this empirical study may contribute to the evolving literature on SCF. Existing studies have largely ignored the SCF impact on a core firm's financial behaviour. In the meantime, literature on cash holdings often focuses on ordinary firms without a SCF focus. As a result, the link between SCF and a core firm's cash holdings may be a helpful extension to the literature. Second, the mechanism of SCF may be further explored in the context of the largest emerging market. Given the noticeable growth of SCF in recent years, such exploration may be useful to better understand this impactful financial innovation, especially for the supply chains connecting large numbers of SMEs with real economy. The recent Trade War in 2018 and the Covid-19 Pandemic in 2020 may have imposed tangible financial pressure on supply chains in the world economy. Such an examination may assist an understanding of a core firm's financial status and subsequent functioning in the restoration of supply chains. Third, the listed firms on Shanghai and Shenzhen Stock Exchanges often take a lead in reforming the SOEs in the largest bank-based economy. Given the preference of banks for lending to SOEs and the outstanding financial constraints of private firms or SMEs, such a discussion of SCF impact on firms of various ownership and size may shed light on effective financial solutions in future studies. Fourth, our findings may have policy implications in the emerging market contexts. SCF may have an impact on a firm's cash holdings, so the industrial and banking lending policies may need adjustments to further support SCF and the real economy.

The rest of the paper is structured as follows. Part 2 reviews the literature and develops our research hypotheses. Part 3 outlines data and methodology. Part 4 analyses our results and Part 5 concludes the paper.

2. Literature review and hypotheses development

The core firm often plays key roles in the supply chain. Besides designing the SCF, the core firm also provides credit and information to other firms. The SCF-based network allows better management of material, information, and cash flows (Liebl et al., 2016; Wuttke et al., 2019). The core firm may organically integrate finance and business operations among firms in the supply chain (Lin and Zhang, 2020; Song et al., 2020). The competitiveness of firms, including SMEs, can be significantly enhanced through optimal inter-firm capital flows and efficiency of cash flow management (Wuttke et al., 2013a). The cash flow management in SCF may lead to a different level of cash holdings at the core firm. Evidence from developed markets suggests that SCF may shorten the period of accounts receivable while increasing that of accounts payable (Hofmann and Kotzab, 2010). As a result, SCF may enhance the efficiency of capital flows and demonstrate higher cash holdings at the core firm (Lamoureux and Evans, 2011).

Given the features of bank-based economic fundamentals (Levine, 2002; Allen et al., 2005), the emergence of SCF and subsequent cash holdings by the core firm may be largely related to the core firm's ties with its major creditors, especially the banks. On one hand, the core firm in SCF may demonstrate better risk control through such innovative financial solutions as factoring and reverse factoring, which reduce the risk of bankruptcy in the supply chain (Klapper, 2006; Lekkakos and Serrano, 2016). On the other hand, banks may infiltrate more borrowers through accurate information from the core firm in SCF (Caridi et al., 2010; Hofmann, 2014). Under noticeable information asymmetry, banks in China are often reluctant to lend to private firms or SMEs (Wu and Xu, 2020; Li et al., 2018).

1 For example, PBC (2016) No. 42 Document, “Several opinions of the People's Bank of China, the National Development and Reform Commission, the Ministry of Industry and Information Technology, and other authorities on financial support for the industrial sector in stabilizing growth, adjusting structure and heightening benefits”, was issued on 14 February 2016. Another example can be State Council (2017) No. 84 Document on “Active guidance on supply chain innovation and application” issued on 5 October 2017.

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Given the nature of their business scope, most firms in the network and information sector are service providers to the core firms in other sectors. Innovative financial solutions within the core firm may also contribute to increased commission fees for the banks besides better risk management of loans to the supply chain. Such a new relationship with firms in the supply chain may be preferred by the fast expanding Chinese banks since the GFC, as they previously competed against each other with similar products and services (Allen et al., 2005; Xu and Lin, 2007; Xu et al., 2015). In addition, since interest income is the most important source of income for Chinese banks, there may be incentives for them to push their lending to the core firm in SCF. As a result, the core firm may increase its cash holdings to ensure sufficient liquidity in the supply chain.

Based on the above theoretical discussion, we develop our first hypothesis as follows.

**Hypothesis 1.** Ceteris paribus, SCF positively contributes to more cash holdings at the core firm.

However, excessive cash holdings may also lead to various agency issues. Firm executives may take advantage of excessive cash holdings for personal benefits and subsequently destroy firm values (Myers and Rajan, 1998; Pinkowitz et al., 2006; Dittmar and Mayhew-Smith, 2007). On the contrary, insufficient cash holdings may induce liquidity issues in the supply chain with increased risk of bankruptcy. As a result, the core firm may need to achieve a dynamic balance between the marginal earnings and cost of cash holdings. In other words, the optimal cash holdings by the core firm in SCF may be affected by its economic consequences. When cash holdings contribute more marginal revenue than marginal cost, the core firm tends to increase its cash holdings. As a result, the core firm in SCF may need to consider its optimal cash holdings to meet its various targets.

Given the slowing market and increased competition among Chinese firms in recent years (He et al., 2019; Wu and Xu, 2020), SCF may need to better enhance the competitiveness of firms within the supply chain (Wuttke et al., 2013b; Wuttke et al., 2019). Existing studies often suggest that cash holdings often inevitably impact on a firm’s competitiveness in the marketplace. Sufficient cash holdings may enable the firm to better execute its strategies, such as R&D investments, mergers and acquisitions (M&As), or predatory pricing, and take more market share away from its competitors (Haushalter et al., 2007; Fresard, 2010). Similarly, the core firm in SCF may take advantage of its financial network, including its ties to banks, to gain comparative advantages exclusive of its competitors. SCF may improve trust, commitment, and profitability of firms in the supply chain, which subsequently improves their access to bank loans and lowers funding costs (Randall and Farris, 2009; Camerinelli, 2009; Lamoureux and Evans, 2011). The lowered funding costs among firms in the supply chain may further improve the competitiveness of the core firm.

Based on the above theoretical discussion, we develop our second hypothesis as follows.

**Hypothesis 2.** Ceteris paribus, improved cash holdings positively contribute to improved competitiveness of the core firm.

### 3. Sample and research methodology

#### 3.1. Sample

We adopt all listed firms on the Shanghai and Shenzhen Stock Exchanges between 2011 and 2017 as our initial sample. We first manually collect SCF information from the firms’ financial reports, public announcements, and Baidu searches. Excluding financial firms and those without SCF commitment, we have 344 sample firms. Then we further exclude firms from the network and information industry, those starting SCF in 2017, those without a clear record of SCF starting year, or those without a clear business scope. Eventually, we have 118 effective sample core firms, which play key roles in industrial chains and are core firms providing financial support to their up- and down-stream firms in SCF. Table 1 reports the distribution of these sample firms. We further use firm size, internal control quality, governance, profitability, leverage, capital expenditure, non-cash assets, sales and year as controls for the closest propensity score matching (PSM) at a ratio of 1:4. We get 438 listed firms without SCF commitment in our comparison group.

We derive financial data of the 556 listed firms from CSMAR and WIND databases. Where there is data missing from the databases, we apply manually collected data from the firms’ financial statements. We also collect firm internal control data from the DIB database. We then winsorize the collected data at 1% significance level to remove extreme values.

#### 3.2. Research methodology

Cash holdings and competitiveness of firms would be the key variables in this study. Following Kalcheva and Lins (2007), we define cash holdings ($Z_{cash}$) as (cash + short-term investment or trading securities)/total assets. To identify change in cash holdings, we adopt $\Delta Z_{cash}$ as a dependent variable in this study. $\Delta Z_{cash} = (\text{cash holdings in the year after SCF commitment} - \text{cash holdings in } t)$

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2 Given the nature of their business scope, most firms in the network and information sector are service providers to the core firms in other sectors. As a result, they are not identified as core firms in SCF.

3 Our comparison group has ATT values lower than 1.69. t-test results also suggest that core firms in SCF and comparison samples are not significantly different in the selected control variables. The data balance test results also suggest that the samples for comparison purpose are acceptable. In addition, it should be noted that the 438 control sample enterprises do not include the excluded samples from the 344 original enterprises.

4 The DIB database provides an internal control index of listed Chinese firms. In conformity with the regulatory requirements, the DIB index is developed on the listed firm’s internal control evaluation reports, internal control audit reports and annual reports. The DIB database has been accepted by a growing number of studies on Chinese firms.
the year before SCF commitment)/total assets in the year before SCF commitment. Following Fresard (2010), we adopt competitive advantage (Com), measured as the difference in growth rate of operation income between the firm and the industry average, to measure the firm’s competitiveness in the market.

We also adopt a list of other variables, which include a dummy variable (SCF) indicating whether the firm is engaged in SCF, firm size (Size), firm internal control quality (Vic), firm growth (Growth), governance (Gov), profitability (ROA), leverage (Lev), capital expenditure (Capexp), non-cash assets (Ncash), sales cost (Sales), state ownership (State), and industry (Ind). Table 2 defines the detailed measurement of variables in our primary tests.

To test our hypotheses H1, we develop the following Eq. (1) for empirical test.

$$\Delta Zcash = \beta_0 + \beta_1 SCF + \beta_2 Size + \beta_3 Vic + \beta_4 Growth + \beta_5 Gov + \beta_6 ROA + \beta_7 Lev + \beta_8 Capexp + \beta_9 Ncash + \beta_{10} Sales + \beta_{11} State + \beta_{12} Ind + \epsilon$$

(1)

As indicated in our H1, we expect the coefficients in Eq. (1) to be positive. In other words, the core firm has more cash holdings after commitment to SCF than that before commitment.

To test our hypothesis H2, we develop the following Eqs. (2) and (3) for empirical test.

$$Com = \beta_0 + \beta_1 \Delta Zcash + \beta_2 Size + \beta_3 Vic + \beta_4 Growth + \beta_5 Gov + \beta_6 ROA + \beta_7 Lev + \beta_8 Capexp + \beta_9 Ncash + \beta_{10} Sales + \beta_{11} State + \beta_{12} Ind + \epsilon$$

(2)

$$Com = \beta_0 + \beta_1 \Delta Zcash + \beta_2 Size + \beta_3 Vic + \beta_4 Growth + \beta_5 Gov + \beta_6 ROA + \beta_7 Lev + \beta_8 Capexp + \beta_9 Ncash + \beta_{10} Sales + \beta_{11} State + \beta_{12} Ind + \epsilon$$

(3)

Eqs. (2) and (3) respectively test the relation between SCF and Zcash and $\Delta Zcash$. As indicated in our hypothesis H2, we expect the coefficients in Eqs. (2) and (3) to be positive. In other words, more cash holdings improve the core firm’s competitiveness.
4. Result analysis

4.1. Statistical summary

Table 3 presents the statistical summary of our variables in our primary tests. The mean of Zcash is similar between the SCF and comparison groups. The mean of △Zcash of the core firm group is significantly higher than that of the comparison group. Within the core firm group, △Zcash has a minimum of 0, suggesting that no core firm decreases cash holdings in our sample. However, certain firms in the comparison group witness decreases in cash holdings. Interestingly, Com has a negative mean value in both groups, suggesting that the sample firm’s competitiveness is close to the industrial average. If we consider the time lag on improved firm competitiveness in the market, Com values in both groups may not show any clear pattern at this stage. If we ignore the possible time lag of SCF impact, the two groups have similar competitiveness values, further suggesting the comparability of our sample firms. Other variables also suggest that the selection of comparison samples does not have an obvious bias issue.
4.2. Measurement results

Our primary test results from Eqs. (1) and (2) are reported in Table 4. Column (1) results show that SCF and \( \Delta Zcash \) are significantly and positively related in our full sample, supporting our H1. In addition, Size is positively related to \( \Delta Zcash \), but Ncash and State are negatively related to \( \Delta Zcash \). These results suggest that larger firms may have more improvement in cash holdings. However, non-cash assets and state ownership tend to be negative towards increases in the firm’s cash holdings. Column (2) reports that Com is significantly and positively related to SCF, supporting our H2. However, Com is negatively related to Size, Growth, Gov, Lev, and Ncash among all sample firms. Columns (3) and (5) respectively suggest that the core firm’s Zcash and \( \Delta Zcash \) are significantly and positively related to Com. However, such relations do not exist in the comparison group. In addition, Size and Growth significantly and negatively contribute to the core firm’s Com, but without significant relation to the comparison group. Gov is significantly and positively related to Com in Column (3) but not significant in Column (5). However, Gov is significantly and negatively related to Com in Columns (4) and (6), suggesting that governance on average improves the core firm’s competitiveness, while reducing firm competitiveness in the comparison group. In short, both H1 and H2 are supported by our primary test results.

4.3. Mechanism test

To explore the mechanism underlying our findings in 4.2, we examine how SCF works on increasing the core firm’s cash holdings and competitiveness. For this purpose, we adopt three operating performance indicators of the core firm in the year before committing to SCF. They are accounts receivable turnover (operating income/accounts receivable), accounts payable turnover (operating income/accounts payable), and inventory turnover (operating cost/inventory balance). Using the median of each indicator, we divide our whole sample into high and low groups. In addition, following Farris and Hutchison (2002), we use the cash turnover period (CCC)\(^5\) as a measurement of capital efficiency in SCF and develop the following Eq. (4) for empirical test.

\[
CCC = \alpha_0 + \alpha_1SCF + \alpha_2Size + \alpha_3Vic + \alpha_4Growth + \alpha_5Gov + \alpha_6ROA + \alpha_7Lev + \alpha_8Capexp + \alpha_9Ncash + \alpha_{10}Sales + \alpha_{11}State + \varepsilon
\]

\(^5\) CCC has been widely used in management accounting as a key measurement of working capital efficiency. Stewart (1995) defines it as the average number of days required in the conversion of 1 dollar valued raw material to 1 dollar received from customers. CCC has three components, accounts receivable turnover period (payback time of accounts receivable), accounts payable turnover period (operating income/accounts payable), and inventory turnover (operating cost/inventory balance). Using the median of each indicator, we divide our whole sample into high and low groups. In addition, following Farris and Hutchison (2002), we use the cash turnover period (CCC) as a measurement of capital efficiency in SCF and develop the following Eq. (4) for empirical test.
Table 4
Primary test results.

| Variables (1) | (2) | (3) | (4) | (5) | (6) |
|--------------|-----|-----|-----|-----|-----|
| SCF          | 0.103*** | 0.101** | 1.137* | −0.360 | 0.356* |
|              | (0.56) | (2.09) | (1.68) | (−0.83) | (1.77) |
| Zcash        | 0.019* | −0.036* | −0.094* | −0.016 | −0.110* |
|              | (1.88) | (−1.66) | (−1.72) | (−0.65) | (−1.86) |
| Growth       | 0.001 | −0.065*** | −0.102* | −0.060*** | −0.109* |
|              | (0.15) | (−3.28) | (−1.76) | (−2.99) | (−1.79) |
| Gov          | −0.085 | −0.992* | 1.398* | −1.528*** | 1.149 |
|              | (−0.68) | (−1.94) | (1.72) | (−2.67) | (1.51) |
| ROA          | 0.188 | 0.087 | −0.003 | 0.125 | 0.120 |
|              | (0.93) | (0.15) | (−0.00) | (0.16) | (0.19) |
| LeV          | 0.019 | −0.268** | −0.011 | −0.322* | 0.158 |
|              | (0.38) | (−2.08) | (−0.06) | (−1.97) | (0.63) |
| Capexp       | 0.157 | 1.088 | 2.128 | 0.632 | 1.984 |
|              | (0.46) | (1.30) | (1.28) | (0.60) | (1.19) |
| Ncash        | −0.268** | −0.395* | 1.319* | −0.668* | 0.700 |
|              | (−2.34) | (−1.82) | (1.86) | (−1.94) | (1.66) |
| Sales        | −0.242 | 0.140 | −0.018 | 0.297 | 0.023 |
|              | (−1.02) | (0.34) | (−0.01) | (0.61) | (0.02) |
| State        | −0.029* | −0.071 | −0.087 | −0.058 | −0.051 |
|              | (−1.71) | (−1.35) | (−1.23) | (−0.86) | (−0.69) |
| Ind          | Yes | Yes | Yes | Yes | Yes |
| Constant     | −0.092 | 1.591*** | 0.694 | 1.585* | 1.738 |
|              | (−0.42) | (2.77) | (0.63) | (2.12) | (1.49) |
| Observation  | 556 | 556 | 118 | 438 | 118 |
| Adjusted R²  | 0.083 | 0.123 | 0.101 | 0.047 | 0.102 |

Note:***, ** and * respectively indicate significance level at the 1%, 5% and 10%. This table reports our primary test results on H1 and H2 through Eqs. (1)–(3). We expect the coefficients in Eqs. (1)–(3) to be positive, i.e. the core firm has more cash holdings after commitment to SCF and more cash holdings improve its competitiveness.

$$\Delta Zcash = \alpha_0 + \alpha_1\text{SCF} + \alpha_2\text{Size} + \alpha_3\text{Vic} + \alpha_4\text{Growth} + \alpha_5\text{Gov} + \alpha_6\text{Lev} + \alpha_7\text{Capexp} + \alpha_8\text{Ncash} + \alpha_9\text{Sales} + \alpha_10\text{State} + \alpha_11\text{Ind} + \epsilon$$ (1)

$$\text{Com} = \beta_0 + \beta_1\Delta \text{Zcash} + \beta_2\text{Size} + \beta_3\text{Vic} + \beta_4\text{Growth} + \beta_5\text{Gov} + \beta_6\text{Lev} + \beta_7\text{Capexp} + \beta_8\text{Ncash} + \beta_9\text{Sales} + \beta_10\text{State} + \beta_11\text{Ind} + \epsilon$$ (2)

$$\Delta Zcash = (\text{cash holdings in the year after SCF commitment} – \text{cash holdings in the year before SCF commitment})/\text{total assets in the year before SCF commitment}. \text{Com, measured as the difference in growth rate of operation income between the firm and the industry average, to measure the firm's competitiveness in the market. Other variables please refer to Table 2.}$$

Table 5 reports our measurement results by Eq. (4). Columns (1) and (2) show significant and positive links between SCF and $$\Delta Zcash$$, however, the coefficient is larger in the sample with lower accounts receivable turnover, suggesting that SCF has a strong impact on shortening the accounts receivable turnover period and enhancing cash holdings at the core firm. Similarly, SCF is significantly and positively related to $$\Delta Zcash$$ in columns (3) to (6), suggesting SCF also affects accounts payable and inventory turnovers and positively contributes to more cash holdings at the core firm. SCF positively contributes to firm cash holdings among both high and low performing firms in our sample, following the above three indicators. However, the coefficient was larger in the lower sample group and differences in the coefficient between groups passed the permutation test. Column (7) shows the significant and negative relation between SCF and CCC, suggesting that SCF shortens the cash turnover period by around 145 days. Our finding, that SCF significantly improves capital efficiency, is in conformity with that by Lamoureux and Evans (2011) and Ali et al. (2019). Given the outstanding financial constraints among SMEs and private firms in China (Xu et al., 2015; He et al., 2019), such a contribution by SCF may fundamentally change the firm’s competitive position in the market.
4.4. Extended discussion

Following our above analysis, we further extend our examination to commercial credit, relationships with banks, political connections, possible over-investment, and firm value of the core firm.

4.4.1. Commercial credit

Commercial credit may be an alternative to bank loans and alleviate financial constraints (Petersen and Rajan, 1997). In a competitive buyer’s market, a firm of good reputation can access commercial credit provided by suppliers at a low cost. Such credit not only helps suppliers to achieve better sales but also is meaningful in sustaining the business ties within the supply chain (Fabbri and Menichini, 2010; Giannetti et al., 2011). Mismatches between commercial credit and capital needs may put the supply chain in a risky position. Coordinating capital flows in both upstream and downstream firms, the core firm in SCF may need to effectively manage commercial credit and bank loans to reduce the risks to the supply chain and to reduce the cost of capital, which may occur during the transformation of commercial credit to bank loans.

Given the core firm in SCF may need to manage commercial credit of various values, we further examine the commercial credit impact on the core firm’s cash holdings. We use \textit{TradeCredit} as the measurement of commercial credit\footnote{Following Ge and Qiu (2007), \textit{TradeCredit} is calculated as the natural logarithm of a firm’s aggregate of accounts receivable and accounts payable. Given the data constraints and possible needs of frequent trades with other firms in the supply chain, we do not differentiate between commercial credits from upstream or downstream sources.} and develop the following Eqs. (5) and (6) to examine the role of commercial credit in SCF.

\begin{equation}
SCF = a_0 + a_1 \text{TradeCredit} + a_2 \text{Size} + a_3 \text{Vic} + a_4 \text{Growth} + a_5 \text{Gov} + a_6 \text{ROA} + a_7 \text{Lev} + a_8 \text{Capexp} + a_9 \text{Ncash} + a_{10} \text{Sales} + a_{11} \text{State} + a_{12} \text{Ind} + \varepsilon
\end{equation}

Note: ***, ** and * respectively indicate significance level at the 1%, 5% and 10%.

This table reports Eq. (4) test results on SCF mechanism.

\begin{equation}
\text{CCC} = \alpha_0 + \alpha_1 \text{SCF} + \alpha_2 \text{Size} + \alpha_3 \text{Vic} + \alpha_4 \text{Growth} + \alpha_5 \text{Gov} + \alpha_6 \text{ROA} + \alpha_7 \text{Lev} + \alpha_8 \text{Capexp} + \alpha_9 \text{Ncash} + \alpha_{10} \text{Sales} + \alpha_{11} \text{State} + \varepsilon
\end{equation}

\text{CCC} is the cash turnover period as a measurement of capital efficiency in SCF. Other variables please refer to Table 2.
Following Richardson (2006), we develop the following models to examine firm's possible over-investment. Given that political connections in China often play an important role in such firm policies as cash holdings (Faccio, 2006; Liu and Tian, 2012; Xu et al., 2016; He et al., 2019), we further examine the effect of political connections on the core firm's cash holdings. Considering that the president and CEO are decisive members of the senior management in firm operation, we follow Fan et al. (2007) in defining firm political connections and develop the following Eq. (8) for such a measurement.

$$
\Delta Z_{\text{cash}} = \alpha_{0} + \alpha_{1}\text{TradeCredit} + \alpha_{2}\text{Size} + \alpha_{3}\text{Vic} + \alpha_{4}\text{Growth} + \alpha_{5}\text{Gov} + \alpha_{6}\text{ROA} + \alpha_{7}\text{Lev} + \alpha_{8}\text{Capexp} + \alpha_{9}\text{Ncash} + \alpha_{10}\text{Sales} + \alpha_{11}\text{State} + \alpha_{12}\text{Ind} + \varepsilon
$$

(6)

Table 6 reports the measurement results of Eqs. (5) and (6). TradeCredit is significantly and positively related to SCF in the full sample, suggesting that firms with more commercial credit are more likely to commit to SCF. In other words, commercial credit is an important factor leading to SCF. Columns (2) and (3) suggest that SOEs are more likely to commit to SCF than private firms. SOEs are often better supported in various means by the government (Xu and Lin, 2007; He et al., 2019; Li et al., 2020b). Access to more commercial credit does not always induce private firms to commit to SCF. This may be largely attributed to the financial constraints of private firms, which require them to be prudent with their commercial credit and better manage their risks in the market. The results in columns (4) and (5) further suggest that, despite significant and positive contributions to firm's cash holdings in both groups, the lower commercial credit group demonstrates stronger impact. In other words, a firm with lower commercial credit tends to hold more cash. This result may be related to the fact that SCF only recently started in the country. Given the existence of information asymmetry, banks may tend to lend more to a core firm with more commercial credit. Subsequently, firms with lower commercial credit may have to increase cash holdings to survive in an uncertain market.

4.4.2. Bank relationship

In the largest bank-based economy, the relationship with banks may also contribute to the firm's resources (Levine, 2002; Fu et al., 2015; Xu et al., 2015). A good relationship with banks may also be significant towards SCF. To measure the bank-firm relationship, we use a proxy BC to indicate whether bank and firm hold each other's shares or whether the firm executive has a banking background. We examine the role of bank relationships with the following Eq. (7).

$$
\Delta Z_{\text{cash}} = \alpha_{0} + \alpha_{1}\text{SCF} + \alpha_{2}\text{BC} + \alpha_{3}\text{BC} \times \text{SCF} + \alpha_{4}\text{Growth} + \alpha_{5}\text{Gov} + \alpha_{6}\text{ROA} + \alpha_{7}\text{Lev} + \alpha_{8}\text{Capexp} + \alpha_{9}\text{Ncash} + \alpha_{10}\text{Sales} + \alpha_{11}\text{State} + \alpha_{12}\text{Ind} + \varepsilon
$$

(7)

Table 7 reports the measurement results of Eq. (7). BC and SCF are significantly and positively related in the full sample, suggesting that bank relationship is an important external factor in the firm to committing to SCF. However, there is no significant link identified between BC or BC×SCF and ΔZcash. In other words, good bank relationships do not necessarily contribute to improved cash holdings among sample firms. The examination of firm ownership shows that BC and ΔZcash are significantly and positively related in the SOE group but not in the private firm group. However, BC×SCF and ΔZcash are significantly and positively related in the private firm group. These results suggest that state ownership still decides a firm's access to bank loans, which is significant towards the firm's cash holdings among SOEs. Good bank relationships and SCF may not always result in improved cash holdings within SOEs. When both good bank relationships and SCF exist, private firms may show significantly improved cash holdings. In short, good bank relationships may contribute to more cash holdings in the core firm.

4.4.3. Political connections

Given that political connections in China often play an important role in such firm policies as cash holdings (Faccio, 2006; Liu and Tian, 2012; Xu et al., 2016; He et al., 2019), we further examine the effect of political connections on the core firm's cash holdings. Considering that the president and CEO are decisive members of the senior management in firm operation, we follow Fan et al. (2007) in defining firm political connections and develop the following Eq. (8) for such a measurement.

$$
\Delta Z_{\text{cash}} = \alpha_{0} + \alpha_{1}\text{POL} + \alpha_{2}\text{POL} \times \text{SCF} + \alpha_{3}\text{Growth} + \alpha_{4}\text{Gov} + \alpha_{5}\text{ROA} + \alpha_{6}\text{Lev} + \alpha_{7}\text{Capexp} + \alpha_{8}\text{Ncash} + \alpha_{9}\text{Sales} + \alpha_{10}\text{State} + \alpha_{11}\text{Ind} + \varepsilon
$$

(8)

Where POL is the political connection by the firm's president and CEO, indicating whether he or she has such experience as a government official, an army officer, standing committee member or member of the People's Congress or CPPCC. If yes, POL equals to 1, otherwise 0.

Table 8 reports our test results on political connections. Among all sample firms, POL is significantly and positively related to ΔZ-cash, confirming that political connections are significant towards the firm's cash holdings. Furthermore, POL×SCF is significantly and positively related to ΔZ-cash, suggesting that political connections have positive impacts on the core firm's cash holdings. Political connections may signal better reputation and support from the government towards creditors and towards the SCF, and subsequently allow the core firm to improve its cash holdings. However, such an impact only exists among the privately owned core firms, not the state-owned ones. In other words, since SOEs naturally enjoy political connections, participating in SCF would not noticeably improve their cash holdings. In short, private ownership with political connections may further improve the core firm's cash holdings.

4.4.4. Firm investment

It can be interesting to examine the core firm's over-investment issue when SCF contributes to more cash holdings. Following the literature discussion in Part 2, we further examine the consequence of increased cash holdings at the core firm on its investment. Following Richardson (2006), we develop the following models to examine firm's possible over-investment.

$$
\text{Inv}_{i,t} = \alpha_{0} + \alpha_{1}\text{Inv}_{i,t-1} + \alpha_{2}\text{Tobin'sQ} + \alpha_{3}\text{CF}_{i,t-1} + \alpha_{4}\text{ROA}_{i,t-1} + \alpha_{5}\text{Size}_{i,t-1} + \varepsilon_{i,t-1}
$$

(9)

Where Inv is the firm's investment, measured as (the net changes in fixed assets, building-in-progress, intangible assets, and long-term investments)/total assets. CFO is the net cash flow from operations. Then the residual in Eq. (9) is used as the over-investment

---

7 BC is a dummy variable. It equals to 1 if the bank and firm holds each other's shares or a firm executive has a banking background, otherwise, 0.
In the above Eqs. (10)–(12), OverInv is the over-investment by the core firm. A smaller value in OverInv corresponds to better investment efficiency and less likelihood of over-investment. Controls refers to the control variables of Size, Vic, Growth, etc. that we use in previous examinations. FCF is the firm’s free cash flow, measured as (net profit + depreciation – common share dividends)/total assets.

Table 9 reports our measurement results on the core firm’s investment. Zcash and △Zcash are significantly and negatively related to OverInv, suggesting that increased cash holdings at the core firm may not lead to over-investment. On the contrary, the more cash holdings the core firm has, the higher investment efficiency may be achieved. One possible explanation can be that SCF effectively alleviates the core firm’s financial constraints and subsequently allows improved investment efficiency. In other words, SCF may

8 Considering the small sample of core firms in SCF, we adopt the absolute value of the residual in Eq. (8) as OverInv, where positive coefficients indicate low investment efficiency and possible over-investment, while negative coefficients indicate investment efficiency proportional to a firm’s cash holding and no over-investment.

### Table 6
Commercial credit test results.

| Variable     | (1)          | (2)          | (3)          | (4)          | (5)          |
|--------------|--------------|--------------|--------------|--------------|--------------|
|              | Whole sample | SOEs         | Private firms| High commercial credit scale | Low commercial credit scale |
| SCF          |              |              |              | △Zcash       | △Zcash       |
| Trade-Credit | 0.112***     | 0.312***     | 0.071        | 0.052**      | 0.136***     |
|              | (3.23)       | (2.80)       | (1.64)       | (2.51)       | (3.82)       |
| Size         | 0.210        | 0.253        | 0.126        | 0.084        | 0.034**      |
|              | (1.49)       | (1.02)       | (0.54)       | (0.29)       | (2.65)       |
| Vic          | -0.106       | -0.365       | -0.273       | 0.012        | -0.018       |
|              | (-0.42)      | (-0.77)      | (-0.81)      | (0.73)       | (-0.72)      |
| Growth       | 0.094        | 0.112        | 0.094        | 0.011        | -0.005       |
|              | (1.19)       | (0.36)       | (0.99)       | (1.11)       | (-0.89)      |
| Gov          | -1.191       | -2.170       | 0.308        | -0.092       | 0.166        |
|              | (-0.53)      | (-0.47)      | (0.10)       | (-0.72)      | (0.71)       |
| ROA          | -2.486       | 9.132        | -2.753       | 0.207        | 0.281        |
|              | (-0.89)      | (1.23)       | (-0.72)      | (0.80)       | (1.01)       |
| Lev          | -1.311*      | -2.371       | -0.948       | 0.040        | 0.032        |
|              | (-1.86)      | (-1.58)      | (-0.94)      | (0.76)       | (0.47)       |
| Capexp       | -2.509       | -22.913*     | 1.966        | -0.297       | 0.434        |
|              | (-0.44)      | (-1.68)      | (0.21)       | (-0.88)      | (0.77)       |
| Ncash        | 2.078        | 4.187        | 2.211        | -0.208*      | -0.325**     |
|              | (1.55)       | (1.74)       | (1.28)       | (-1.73)      | (-2.17)      |
| Sales        | 4.207        | 16.710*      | -1.091       | -0.137       | -0.699*      |
|              | (1.13)       | (1.83)       | (-0.25)      | (-0.63)      | (-1.67)      |
| State        | -0.295       | -0.386       | -0.026       | -0.057**     | -0.222       |
|              | (-1.03)      | (-1.56)      | (1.56)       | (2.22)       | (0.56)       |
| Ind          | Yes          | Yes          | Yes          | No           | No           |
| Constant     | -8.919***    | -15.848**    | -7.538       | 0.160        | -0.488       |
|              | (-2.59)      | (-2.57)      | (-1.28)      | (0.73)       | (-1.56)      |
| Observations | 556          | 217          | 339          | 278          | 278          |
| Pseudo R²    | 0.127        | 0.265        | 0.151        | 0.035        | 0.131        |
| Adjusted R²  | 0.098        | 0.109        | 0.110        | 0.109        | 0.110        |

Note: ** and * respectively indicate significance level at the 1%, 5% and 10%.

This table reports our test results through Eqs. (5)–(6). SCF = α_0 + α_1 TradeCredit + α_2 Size + α_3 Vic + α_4 Growth + α_5 Gov + α_6 ROA + α_7 Lev + α_8 Capexp + α_9 Ncash + α_10 Sales + α_11 State + α_12 Ind + ε (5)

△Zcash = α_0 + α_1 TradeCredit + α_2 Size + α_3 Vic + α_4 Growth + α_5 Gov + α_6 ROA + α_7 Lev + α_8 Capexp + α_9 Ncash + α_10 Sales + α_11 State + α_12 Ind + ε (6)

TradeCredit as the measurement of commercial credit. Other variables please refer to Table 2.
liberate the core firm to make better investments and achieve enhanced economic benefits. This may further support our primary test findings that improved cash holdings by the core firm is positive towards its competitiveness in the market.

4.4.5. Firm value

It can also be meaningful to explore the changes in a core firm’s value when SCF improves its cash holdings. On the one hand, improved cash holdings may allow the firm to take advantage of good investment opportunities, respond quickly to demands from the market, gain better growth opportunities, and subsequently enhance the firm value. On the other, with improved cash holdings, the core firm may better cope with risks in the SCF ecosystem, which is needed for improved firm values. Considering that economic value added and Tobin’s Q \(^9\) may both be used to measure firm value, we develop Eqs. (13) and (14) in our additional tests.

\[
\text{EVA} = \alpha_0 + \alpha_1 \text{SCF} + \alpha_2 \text{Z-cash} + \alpha_3 \text{Z-cash} \times \text{SCF} + \alpha_4 \text{Gov} + \alpha_5 \text{ROA} + \alpha_6 \text{Lev} + \alpha_7 \text{Capexp} + \alpha_8 \text{Ncash} + \alpha_9 \text{Sales} + \alpha_{10} \text{State} + \alpha_{11} \text{Ind} + \varepsilon
\]

\[
\text{Tobin’s } Q = \alpha_0 + \alpha_1 \text{SCF} + \alpha_2 \text{Z-cash} + \alpha_3 \text{Z-cash} \times \text{SCF} + \alpha_4 \text{Gov} + \alpha_5 \text{ROA} + \alpha_6 \text{Lev} + \alpha_7 \text{Capexp} + \alpha_8 \text{Ncash} + \alpha_9 \text{Sales} + \alpha_{10} \text{State} + \alpha_{11} \text{Ind} + \varepsilon
\]

Table 10 reports our test results on firm values. \(\text{SCF} \times \text{Z-cash}\) is significantly and positively related to all firm value measurements, suggesting that improved cash holdings at the core firm also enhance the firm values.

\[^9\] Gomm (2010) suggests that EVA may also be appropriate to measure firm value in SCF context. Accordingly, we respectively use \(\text{EVA} = \text{EVA} = \text{(the core firm’s economic value added)/(the core firm’s average net assets)}\) and Tobin’s Q in our models Eqs. (13) and (14). In addition, we use \(\Delta \text{Tobin’s } Q\) and \(\Delta \text{EVA}\) with a time lag to illustrate the changes in firm value.

---

**Table 7**

| Variables | (1) Whole sample | (2) Whole sample | (3) SOEs | (4) Private firms |
|-----------|----------------|-----------------|---------|----------------|
| **SCF**   | 0.074\(^{*}\) | 0.179\(^{***}\) | 0.034   |                 |
|           | (2.34)         | (2.94)          | (0.88)  |                 |
| **BC**    | 0.479\(^{*}\) | 0.012           | 0.033\(^*\) | -0.006         |
|           | (1.67)         | (0.65)          | (1.78)  | (-0.20)        |
| **BC \times SCF** | 0.035         | -0.086          | 0.994\(^*\) |                 |
|           | (0.87)         | (-1.25)         | (1.76)  |                 |
| **Size**  | 0.144          | 0.018\(^*\)    | -0.009  | 0.031          |
|           | (1.26)         | (1.83)          | (-1.14) | (1.60)         |
| **Vic**   | 0.054          | -0.008          | -0.009  | -0.012         |
|           | (0.25)         | (-0.51)         | (-0.52) | (-0.43)        |
| **Growth**| 0.015          | 0.001           | -0.006  | 0.003          |
|           | (0.17)         | (0.10)          | (-0.54) | (0.37)         |
| **Gov**   | -1.341         | -0.092          | -0.224  | -0.018         |
|           | (-0.75)        | (-0.72)         | (-1.35) | (-0.09)        |
| **ROA**   | -3.115         | 0.180           | 0.329   | 0.093          |
|           | (-1.11)        | (0.88)          | (1.19)  | (0.32)         |
| **Lev**   | -0.757         | 0.021           | -0.022  | 0.051          |
|           | (-1.26)        | (0.43)          | (-0.30) | (0.61)         |
| **Capexp**| 2.589          | 0.166           | 0.093   | -0.379         |
|           | (0.53)         | (0.48)          | (0.15)  | (-1.16)        |
| **Ncash** | 1.122          | -0.268\(^*\)   | -0.176  | -0.323\(^*\)  |
|           | (0.96)         | (-2.34)         | (-1.32) | (-2.02)        |
| **Sales** | 1.156          | -0.250          | 0.089   | 0.206          |
|           | (0.46)         | (-1.05)         | (0.30)  | (0.39)         |
| **State** | -0.092         | -0.030          | -0.38   | (-1.76)        |
| **Ind**   | No             | Yes             | Yes     |                 |
| **Constant** | -5.109\(^*\) | -0.088         | 0.390\(^*\) | -0.316     |
|           | (-1.76)        | (-0.40)         | (1.79)  | (-0.73)        |
| **Observations** | 556       | 556            | 217     | 339            |
| **Adjusted R\(^2\)** | 0.014    | 0.082          | 0.251   | 0.054          |

Note:**\(^*\), \(^{**}\) and \(^{***}\) respectively indicate significance level at the 1%, 5% and 10%. This table reports the measurements results of Eq. (7). 

\[
\Delta \text{Z-cash} = \alpha_0 + \alpha_1 \text{SCF} + \alpha_2 \text{BC} + \alpha_3 \text{BC} \times \text{SCF} + \alpha_4 \text{Growth} + \alpha_5 \text{ROA} + \alpha_6 \text{Lev} + \alpha_7 \text{Capexp} + \alpha_8 \text{Ncash} + \alpha_9 \text{Sales} + \alpha_{10} \text{State} + \alpha_{11} \text{Ind} + \varepsilon
\]

(7)

BC to indicate whether bank and firm holds each other’s shares or whether the firm executive has a banking background. Other variables please refer to Table 2.
To ensure reliability of our findings, we redo PSM at 1:3 ratio. In the new sample, we use the core firm’s cash holdings 1 year after SCF commitment minus its cash holdings in the year of SCF commitment to calculate $\Delta Z_{cash1}$ to replace $\Delta Z_{cash}$. Then we repeat our primary tests and find that SCF is still significantly and positively related to the core firm’s cash holdings. Similarly, increased cash holdings are significantly and positively related to the firm’s competitiveness. Then we repeat our examination on commercial credit, bank relationship, and political connections by the core firm and get similar results. Then we change the measurement of $Inv$ to

$$[(\text{changes in original value of fixed assets} + \text{changes in original value of long-term investments})/\text{total assets} – \text{depreciation and amortization}]$$

and redo the test on the core firm’s investment. The results are supportive to our finding. Tests on firm value also show similar results. These results are reported in Table 11. In short, our findings are robust to the new measurements. Given the features of PSM tests, the endogeneity issue is further mitigated in this process.
5. Conclusion

Through the largest sample possible for this empirical study, we find that SCF positively contributes to a core firm’s cash holdings and improves its competitiveness. The mechanism tests suggest that SCF enhances both operating performance and cash turnover of the firm. In addition, such an impact is stronger when the firm is of lower efficiency. Our extended examinations indicate that the firm with more commercial credit or of state ownership will more likely become committed to SCF. Good relationships with banks or political connections may further improve the private firm’s cash holdings. Furthermore, increased cash holdings in the core firm may lead to enhanced investment efficiency, rather than over-investment, and enhanced firm values. Therefore, SCFs contribution to the core firm may go beyond the improved cash holdings and structurally change firm behaviour in the future.

As a meaningful financial innovation in recent years, SCF may have become a strategic choice for firms in the supply chain. However, the reform in the country’s financial market may need to accommodate such changes in the foreseeable future. In our examination of SCF impact on firm cash holdings, we could still identify bias towards private ownership. There may need to be more

| Table 9 |
| --- |
| Over-investment test results. |
| Variables | (1) | (2) | (3) |
| Over-inv | Over-inv | Over-inv |
| Zcash | $-0.030^{**}$ | $-0.032^{***}$ | $-0.013$ |
| ($-2.22$) | ($-2.69$) | ($-1.88$) |
| $\triangle$Zcash | $-0.012^{***}$ | | |
| ($-2.90$) | | |
| FCF | | $-0.013$ | |
| ($0.07$) | | ($-0.65$) |
| Size | $-0.001$ | $0.002$ | $-0.005$ |
| ($0.33$) | ($0.35$) | ($-0.65$) |
| Vic | $-0.004^{*}$ | $-0.005^{**}$ | $-0.004^{*}$ |
| ($-2.09$) | ($-1.88$) | |
| Growth | 0.001 | 0.002 | |
| ($1.31$) | ($0.35$) | |
| Gov | 0.050 | 0.050 | 0.020 |
| ($1.61$) | ($1.78$) | ($1.01$) |
| ROA | $-0.013$ | $-0.012$ | $-0.022$ |
| ($-0.58$) | ($-1.44$) | |
| Leverage | $-0.007$ | $-0.011^{*}$ | $-0.008$ |
| ($-1.18$) | ($-1.47$) | |
| Capexp | 0.063 | 0.064 | 0.066 |
| ($0.83$) | ($1.45$) | |
| Ncash | $-0.043^{**}$ | $-0.024^{*}$ | $-0.013$ |
| ($-2.44$) | ($-1.15$) | ($-0.76$) |
| Sales | $-0.023$ | $-0.011$ | $-0.027$ |
| ($-0.66$) | ($-0.76$) | |
| State | 0.002 | 0.001 | $-0.001$ |
| ($0.61$) | ($0.08$) | ($-0.27$) |
| Ind | No | No | No |
| Constant | 0.040 | 0.009 | 0.022 |
| ($1.46$) | ($0.36$) | ($0.86$) |
| Observations | 118 | 118 | 118 |
| Adjusted $R^2$ | 0.056 | 0.068 | 0.228 |

Note: ***, ** and * respectively indicate significance level at the 1%, 5% and 10%.

This reports our Eqs. (10)–(12) test results.

\[
\begin{align*}
Inv_{t} &= \alpha_0 + \alpha_1 Inv_{t-1} + \alpha_2 \text{Tobin}\text{'s}Q + \alpha_3 CFO_{t-1} + \alpha_4 ROA_{t-1} + \alpha_5 State_{t-1} + \epsilon_{t-1} \\ (9) \\
OverInv_{t} &= \beta_0 + \beta_1 Zcash_{t} + \beta_2 Controls_{t-1} + \epsilon_{t} \\ (10) \\
OverInv_{t} &= \beta_0 + \beta_1 \Delta Zcash_{t} + \beta_2 Controls_{t-1} + \epsilon_{t} \\ (11) \\
OverInv_{t} &= \beta_0 + \beta_1 FCF_{t-1} + \beta_2 Controls_{t-1} + \epsilon_{t} \\ (12)
\end{align*}
\]

Inv is the firm’s investment. CFO is the net cash flow from operations. The residual in Eq. (9) is used to determine over-investment index (OverInv) in Eq. (10)–(12). Other variables please refer to Table 2.

5. Conclusion

Through the largest sample possible for this empirical study, we find that SCF positively contributes to a core firm’s cash holdings and improves its competitiveness. The mechanism tests suggest that SCF enhances both operating performance and cash turnover of the firm. In addition, such an impact is stronger when the firm is of lower efficiency. Our extended examinations indicate that the firm with more commercial credit or of state ownership will more likely become committed to SCF. Good relationships with banks or political connections may further improve the private firm’s cash holdings. Furthermore, increased cash holdings in the core firm may lead to enhanced investment efficiency, rather than over-investment, and enhanced firm values. Therefore, SCFs contribution to the core firm may go beyond the improved cash holdings and structurally change firm behaviour in the future.

As a meaningful financial innovation in recent years, SCF may have become a strategic choice for firms in the supply chain. However, the reform in the country's financial market may need to accommodate such changes in the foreseeable future. In our examination of SCF impact on firm cash holdings, we could still identify bias towards private ownership. There may need to be more
supportive policies in place to allow SCF to play its positive roles in sustaining the economic growth of the largest bank-based economy. Given that a growing number of listed firms commit to SCF, future studies may provide further evidence on SCF's contribution to the real economy.

**Author statement**

The authors do not have permission to share data.

**Declaration of competing interest**

None.
Table 11
Robustness test results.

Panel A

| Variables | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) | (10) |
|-----------|----|----|----|----|----|----|----|----|----|-----|
|           | Whole sample | Whole sample | Whole sample | SCF group | Comparison group | SCF group | Comparison group | Whole sample | SOEs | Private firms |
| △Zcash1   | 0.059*** (5.67) | 0.111*** (4.07) | 0.094*** (4.77) | 0.099*** (4.04) | 0.067** (2.06) |
| Trade-Credit | 0.114*** (3.16) |             |             |             |             |             |
| Zcash     | 1.589** (2.60) | -0.491 (−0.87) | 0.264* (1.87) | 0.068 (0.53) |             |
| POL       |             |             | 0.127*** (7.02) | 0.056** (2.24) | 0.161*** (6.34) |
| POL_SCF   | 0.064+ (1.65) |             |            | -0.060 | 0.096− (-1.04) | 0.096− (-1.67) |
| Controls  | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Ind       | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Constant  | 0.092 (0.86) | 0.204 (0.54) | -3.587 (−1.16) | 0.125 | -0.256 (0.14) | 1.283 | -0.682 (1.36) | -0.126 | 0.268 | 0.096 |
| Observations | 472 | 472 | 472 | 118 | 354 | 118 | 354 | 452 | 171 | 281 |
| Adjusted R2 | 0.097 | 0.091 | 0.131 | 0.078 | 0.121 | 0.069 | 0.193 | 0.308 | 0.199 |
| Pseudo R2 | 0.139 |             |             |             |             |             |

Panel B

| Variables | (1) | (2) | (3) | (4) | (5) | (6) |
|-----------|----|----|----|----|----|----|
|           | Experi-metal group | Experi-metal group | Whole sample | Whole sample | Whole sample | Whole sample |
| FCF       | -0.012 (−0.77) |             |             |             |             |             |
| SCF       | 0.253*** (3.07) | 0.403*** (4.25) | 0.045*** (3.31) | 0.035*** (2.88) |
| Z-cash    | -0.026** (−2.39) | 1.091** (2.10) | -0.143 (0.24) | 0.243*** (2.80) | 0.181** (2.38) |
| SCF×Z-cash | 2.977*** (3.41) | 5.644*** (5.62) | 0.287*** (1.97) | 0.242** (1.90) |
| Controls  | Yes | Yes | Yes | Yes | Yes | Yes |
| Ind       | Yes | Yes | Yes | Yes | Yes | Yes |
| Constant  | 0.038* (1.69) | 0.023 (1.11) | 5.239*** (5.82) | -3.409*** (3.29) | -0.414*** (2.75) | -0.029 (−2.22) |
| Observations | 118 | 118 | 452 | 452 | 452 | 452 |
| Adjusted R2 | 0.079 | 0.208 | 0.349 | 0.201 | 0.129 | 0.0803 |

Note: ***, ** and * respectively indicate significance level at the 1%, 5% and 10%. This table reports our robustness test results. We redo PSM at 1:3 ratio. In the new sample, we use the core firm’s cash holdings 1 year after SCF commitment minus its cash holdings in the year of SCF commitment to calculate ΔZcash1 to replace ΔZcash. Then we repeat our primary tests and find that SCF is still significantly and positively related to the core firm’s cash holdings. Similarly, increased cash holdings are significantly and positively related to the firm’s competitiveness. Then we repeat our additional tests and get similar results. Even when we change the measurement of Inv to [(changes in original value of fixed assets + changes in original value of long-term investments)/total assets – depreciation and amortization], the results are supportive to our findings.

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Appendix A. Propensity score matching (PSM) method

To mitigate the issues of selection bias and functional form misspecification (FFM) in our measurements of supply chain finance and firm cash holdings, we adopt PSM method in the construction of comparison group samples. Setting SCF values of 1 and 0, corresponding to the firm’s commitment to SCF or not, we apply matching variables of Size, Vic, Gov, ROA, Lev, Capexp, Ncash, Sales, and year. At the ratio of 1:4, we use the nearest neighbor matching, to select firms that have the smallest difference in propensity score as that of the core firms in the SCF group. The following are the detailed procedures.

First, we command “set seed 10101”, “Gen TMP = Runiform()” and “sort TMP” are adopted to randomly sort all observations, in statistical software Stata15.

Second, we command “PSmatch2 Treat Size Vic Growth Gov ROA Lev Capexp Ncash Sales year_2 year_3 year_4 year_5 year_6 year_7, out(Zcash) logit neighbor(4) Common caliper(0.05) ties” and achieve the following Tables A-C. Table A illustrates our matching results. Then we judge the matching effect by ATT and t-test values. ATT = -0.004 and \( t = -0.4 \) is less than the critical value of 1.69 (see Table B), suggesting that t-test value conforms to matching requirement by PSM. Similarly, SCF and comparison group firms are in the range of common values (See Table C).

Table A
Matching results.

| SCF     | Coef. | Std.Err. | z     | P  >  z | [95%Conf. Interval] |
|---------|-------|----------|-------|---------|---------------------|
| Size    | 0.578 | 0.075    | 7.700 | 0.000   | 0.431 - 0.725       |
| Vic     | 0.002 | 0.001    | 2.000 | 0.046   | 0.000 - 0.004       |
| Growth  | 0.003 | 0.014    | 0.230 | 0.815   | -0.024 - 0.030      |
| Gov     | -1.884| 1.621    | -1.160| 0.245   | -5.062 - 1.293      |
| ROA     | -0.808| 0.681    | -1.190| 0.235   | -2.142 - 0.526      |
| Lev     | -0.269| 0.457    | -0.590| 0.556   | -1.165 - 0.627      |
| Capexp  | -2.094| 1.114    | -1.880| 0.060   | -4.277 - 0.088      |
| Ncash   | 0.808 | 0.920    | 0.880 | 0.380   | -0.996 - 2.612      |
| Sales   | 2.490 | 2.241    | 1.110 | 0.267   | -1.903 - 6.882      |
| year_2  | 12.052| 582.861  | 0.020 | 0.984   | -1130.335 - 1154.439|
| year_3  | 12.626| 582.861  | 0.020 | 0.983   | -1129.760 - 1155.013|
| year_4  | 14.112| 582.861  | 0.020 | 0.981   | -1128.274 - 1156.498|
| year_5  | 15.015| 582.861  | 0.020 | 0.979   | -1127.371 - 1157.401|
| year_6  | 14.484| 582.861  | 0.020 | 0.980   | -1127.902 - 1156.870|
| _cons   | -32.758| 582.864  | -0.060| 0.955   | -1175.150 - 1109.635|

Table B
ATT and T-test values.

| Variable | Sample | Treated | Controls | Difference | S.E. | T-stat |
|----------|--------|---------|----------|------------|------|--------|
| Zcash    | Unmatched | 0.109   | 0.139    | -0.030     | 0.012| -2.500 |
|          | ATT    | 0.109   | 0.113    | -0.004     | 0.011| -0.400 |

Note: S.E. does not include the estimated propensity scores.
Third, we command “pstest, Both Graph” to test the balance of the matched variables. Table D reports that the bias of all matched variables is less than 10%. Therefore, the matched variables are acceptable. P-values of t-test for all variables after matching are greater than 0.1, confirming that there is no systematic difference in matching variables between the SCF and the comparison groups. Table E and Fig. 1 show the variation of standardized bias after variable matching and the matched data is balanced.

**Table D**

Balance of matched variables test results.

| Variable | Unmatched | Mean | %bias | %reduct | t  | P > | V(T)/V(C) |
|----------|-----------|------|-------|---------|----|-----|-----------|
|          | Matched   | Treated | Control |        |     |     |           |
| Size     | U         | 22.809 | 21.675 | 89.3    | 10.60 | 0.000 | 1.42 |
|          | M         | 22.809 | 22.856 | −3.7    | 95.9  | −0.26 | 0.797 | 0.96 |
| Vic      | U         | 669.99 | 642.94 | 24.4    | 5.5   | 2.16  | 0.030 | 0.34 |
|          | M         | 669.99 | 673.64 | −3.3    | 86.5  | −0.33 | 0.740 | 0.77 |
| Growth   | U         | 2.1997 | 2.7225 | −5.5    | −0.43 | 0.666 | 0.07 |
|          | M         | 2.1997 | 2.1382 | 0.6     | 88.2  | 0.16  | 0.869 | 2.17 |
| Gov      | U         | 0.37293 | 0.37201 | 1.7     | 59.0  | 0.20  | 0.845 | 0.72 |
|          | M         | 0.37293 | 0.37147 | 2.7     | −59.0 | 0.20  | 0.845 | 0.72 |
| ROA      | U         | 0.03826 | 0.0432 | −4.5    | −0.42 | 0.676 | 0.46 |
|          | M         | 0.03826 | 0.04721 | −8.2    | −81.2 | −0.90 | 0.367 | 1.83 |
| Lev      | U         | 0.38966 | 0.3519 | 14.1    | 5.1   | 1.28  | 0.202 | 0.39 |
|          | M         | 0.38966 | 0.36926 | 7.6     | 46.0  | 0.75  | 0.456 | 0.84 |
| Capexp   | U         | 0.01498 | 0.02586 | −21.2   | −1.76 | −1.76 | 0.078 | 0.17 |
|          | M         | 0.01498 | 0.01585 | −1.7    | 92.1  | −0.23 | 0.818 | 0.87 |
| Ncash    | U         | 0.88643 | 0.83835 | 35.1    | 5.1   | 3.35  | 0.001 | 0.56 |
|          | M         | 0.88643 | 0.87957 | 5.0     | 85.7  | 0.47  | 0.638 | 1.17 |
| Sales    | U         | 0.02015 | 0.02262 | −6.8    | −0.68 | −0.68 | 0.500 | 0.71 |
|          | M         | 0.02015 | 0.01942 | 2.0     | 70.5  | 0.14  | 0.888 | 0.55 |
| year_2   | U         | 0.01695 | 0.13105 | −44.6   | −3.67 | −3.67 | 0.000 |      |
|          | M         | 0.01695 | 0.02119 | −1.7    | 96.3  | −0.24 | 0.813 |      |
| year_3   | U         | 0.01695 | 0.14022 | −47.0   | −3.85 | −3.85 | 0.000 |      |
|          | M         | 0.01695 | 0.01483 | 0.8     | 98.3  | 0.13  | 0.897 |      |
| year_4   | U         | 0.0339 | 0.14255 | −39.0   | −3.37 | −3.37 | 0.001 |      |
|          | M         | 0.0339 | 0.05085 | −6.1    | 84.4  | −0.64 | 0.520 |      |
| year_5   | U         | 0.16102 | 0.14581 | 4.2     | 5.3   | 25.4  | 0.41  | 0.68 |
|          | M         | 0.16102 | 0.14195 | 0.8     | 98.3  | 0.13  | 0.897 |      |
| year_6   | U         | 0.45763 | 0.15901 | 68.1    | 8.80  | 8.80  | 0.000 |      |
|          | M         | 0.45763 | 0.46398 | −1.5    | 97.9  | −0.10 | 0.922 |      |
| year_7   | U         | 0.31356 | 0.17688 | 32.1    | 3.86  | 3.86  | 0.000 |      |
|          | M         | 0.31356 | 0.3072 | 1.5     | 95.3  | 0.11  | 0.916 |      |

Note: * if variance ratio outside [0.69; 1.44] for U and [0.69; 1.44] for M.
References

Ali, Z., Bi, G., Mehran, A., 2019. Predicting supply chain effectiveness through supply chain finance. Int. J. Logist. Manag. 30, 488–505.
Allen, F., Qian, J., Qian, M., 2005. Law, finance, and economic growth in China. J. Financ. Econ. 77, 57–116.
Caminerelli, E., 2009. Supply chain finance. J. Payments Strateg. Syst. 3, 114–128.
Caridi, M., Crippa, L., Perego, A., Sianesi, A., Tumino, A., 2010. Measuring visibility to improve supply chain performance: a quantitative approach. Benchmark. Int. J. 17, 593–615.
Danny, L.J., William, F.W., Zach, G.Z., 2010. Concentrated supply chain membership and financial performance: chain- and firm-level perspectives. J. Oper. Manag. 28, 1–16.
Dittmar, A., Marhrt-Smith, J., 2007. Corporate governance and the value of cash holdings. J. Financ. Econ. 83, 599–634.
Fabbri, D., Menichini, A., 2010. Trade credit, collateral liquidation and borrowing constraints. J. Financ. Econ. 96, 413–432.
Faccio, M., 2006. Politically connected firms. Am. Econ. Rev. 96, 369–386.
Fan, J., Wong, T., Zhang, T., 2007. Politically connected CEOs, corporate governance, and post-IPO performance of China’s newly partially privatized firms. J. Financ. Econ. 84, 330–357.
Farris, M., Hutchison, P., 2002. Cash-to-cash: the new supply chain management metric. Int. J. Phys. Distrib. Logist. Manag. 32, 288–298.
Fresard, L., 2010. Financial strength and product market behavior: the real effects of corporate cash holdings. J. Financ. 65, 1097–1122.
Fu, Y., Lee, S.C., Xu, L., Zurbruegg, R., 2015. The effectiveness of capital regulation on bank behaviour in China. Int. Rev. Financ. 15, 321–345.
Ge, Y., Qiu, J., 2007. Financial development, bank discrimination and trade credit. J. Bank. Financ. 31, 513–530.
Gelsomino, L.M., Mangiaracina, R., Perego, A., Tumino, A., 2016. A supply chain finance: a literature review. Int. J. Phys. Distrib. Logist. Manag. 46, 1–19.
Gianetti, M., Burkart, M., Ellingsen, T., 2011. What you sell is what you lend? Explaining trade credit contracts. Rev. Financ. Stud. 24, 1261–1298.
Gomm, M.L., 2010. Supply chain finance: applying finance theory to supply chain management to enhance finance in supply chains. Int J Log Res Appl 13, 133–142.
Haushalter, D., Klaas, S., Maxwell, W., 2007. The influence of product market dynamics on a firm’s cash holdings and hedging behavior. J. Financ. Econ. 84, 797–825.
He, Y., Xu, L., McFver, R., 2019. How does political connection affect firm financial distress and resolution in China? Appl. Econ. 51, 2770–2792.
Hofmann, E., 2014. Inter-Organizational Operations Management, 1st ed. Springer, Wiesbaden.
Hofmann, E., Belin, O., 2011. Supply Chain Finance Solutions, 1st ed. Springer, Berlin.
Hofmann, E., Kotsab, H., 2010. A supply chain-oriented approach of working capital management. J. Bus. Logist. 31, 305–330.
Jia, F., Blome, C., Sun, H., Yang, Y., Zhi, B., 2020. Towards an integrated conceptual framework of supply chain finance: an information processing perspective. Int. J. Prod. Econ. 219, 18–30.
Kalacska, P., Lin, K., 2007. International evidence on cash holdings and expected managerial agency problems. Rev. Financ. Stud. 20, 1087–1112.
Klapper, L.F., 2006. The role of factoring for financing small and medium enterprises. J. Bank. Financ. 30, 3111–3130.
Lamoureux, J.F., Evans, T.A., 2011. Supply Chain Finance: A New Means to Support the Competitiveness and Resilience of Global Value Chains. Working Paper No.2179944. Social Science Research Network, Rochester, New York.
Lekkakos, S.D., Serrano, A., 2016. Supply chain finance for small and medium sized enterprises: the case of reverse factoring. Int. J. Phys. Distrib. Logist. Manag. 46, 367–392.
Levine, R., 2002. Bank-based or market-based financial systems: which is better? J. Financ. Intermed. 11, 398–428.
Li, B., Pan, A., Xu, L., Qin, S., 2020b. Imprinting and peer effects in acquiring state ownership: evidence from private firms in China. Pac. Basin Financ. J. 61, 1013–1037.
Lieber, J.I., Hartmann, E., Feisel, E., 2016. Reverse factoring in the supply chain: objectives, antecedents and implementation barriers. Int. J. Phys. Distrib. Logist. Manag. 46, 393–413.
Lin, Q., Zhang, T., 2020. Trade credit in economic fluctuations and its impact on corporate performance: a panel data analysis from China. Appl. Econ. 52, 1–18.
Liu, Q., Tian, G., 2012. Controlling shareholder, expropriations and firm’s leverage decision: evidence from Chinese non-tradable share reform. J. Corp. Finan. 18, 1013–1037.
Liu, Q., Zhang, T., 2020. Trade credit in economic fluctuations and its impact on corporate performance: a panel data analysis from China. Appl. Econ. 52, 1–18.
Liu, Q., Tian, G., 2012. Controlling shareholder, expropriations and firm’s leverage decision: evidence from Chinese non-tradable share reform. J. Corp. Finan. 18, 1013–1037.
Liu, Q., Tian, G., 2012. Controlling shareholder, expropriations and firm’s leverage decision: evidence from Chinese non-tradable share reform. J. Corp. Finan. 18, 1013–1037.
Liu, Q., Tian, G., 2012. Controlling shareholder, expropriations and firm’s leverage decision: evidence from Chinese non-tradable share reform. J. Corp. Finan. 18, 1013–1037.
Liu, Q., Tian, G., 2012. Controlling shareholder, expropriations and firm’s leverage decision: evidence from Chinese non-tradable share reform. J. Corp. Finan. 18, 1013–1037.
Liu, Q., Tian, G., 2012. Controlling shareholder, expropriations and firm’s leverage decision: evidence from Chinese non-tradable share reform. J. Corp. Finan. 18, 1013–1037.
Liu, Q., Tian, G., 2012. Controlling shareholder, expropriations and firm’s leverage decision: evidence from Chinese non-tradable share reform. J. Corp. Finan. 18, 1013–1037.
Liu, Q., Tian, G., 2012. Controlling shareholder, expropriations and firm’s leverage decision: evidence from Chinese non-tradable share reform. J. Corp. Finan. 18, 1013–1037.
Liu, Q., Tian, G., 2012. Controlling shareholder, expropriations and firm’s leverage decision: evidence from Chinese non-tradable share reform. J. Corp. Finan. 18, 1013–1037.
Liu, Q., Tian, G., 2012. Controlling shareholder, expropriations and firm’s leverage decision: evidence from Chinese non-tradable share reform. J. Corp. Finan. 18, 1013–1037.
More, D., Basu, P., 2013. Challenges of supply chain finance: a detailed study and a Hierarchical model based on the experiences of an Indian Firm. Bus. Process. Manag. J. 19, 624–647.
Myers, S., Rajan, R., 1998. The paradox of liquidity. Q. J. Econ. 113, 733–771.
Nienhuis, J.J., Cortet, M., Lyklama, D., 2013. Real-time financing extending e-invoicing to real-time SME financing. J. Payments Strateg. Syst. 7, 232–245.
People’s Bank of China, 2016. No. 42 Document. Several Opinions of the People’s Bank of China, the National Development and Reform Commission, the Ministry of Industry and Information Technology, and other authorities on financial support for the industrial sector in stabilizing growth, adjusting structure and heightening benefits. http://www.gov.cn/xinwen/2016-02/16/content_5041671.htm (in Chinese) accessed on 16 February 2019.
Petersen, M., Rajan, R., 1997. Trade credit: theories and evidence. Rev. Financ. Stud. 10, 661–691.
Pinkowitz, L., Stulz, R., Williamson, R., 2006. Does the contribution of corporate cash holdings and dividends to firm value depend on governance? A cross-country analysis. J. Financ. 61, 2725–2751.
Polak, P., Simal, R., Hamdan, M., 2012. Post-crisis emerging role of the treasure. Eur. J. Sci. Res. 86, 319–339.
Randall, W., Farris, T., 2009. Supply chain financing: using cash-to-cash variables to strengthen the supply chain. Int. J. Phys. Distrib. Logist. Manag. 39, 669–689.
Richardson, S., 2006. Over-investment of free cash flow. Rev. Acc. Stud. 11, 159–189.
Song, H., Yang, X., Yu, K., 2020. How do supply chain network and SMEs’ operational capabilities enhance working capital financing? An integrative signaling view. Int. Prod. Econ. 230, 107447.
Stewart, G., 1995. Supply chain performance benchmarking study reveals key studies to supply chain excellence. Logistics Information Management 44, 38–317.
Wu, L., Xu, L., 2020. Venture capital certification of small and medium-sized enterprises towards banks: evidence from China. Account. Finance 60, 1601–1632.

Wuttke, D.A., Blome, C., Henke, M., 2013a. Focusing the financial flow of supply chains: an empirical investigation of financial supply chain management. Int. J. Prod. Econ. 145, 773–789.

Wuttke, D.A., Blome, C., Foerstl, K., Henke, M., 2013b. Managing the innovation adoption of supply chain finance – empirical evidence from six European case studies. J. Bus. Logist. 34, 148–166.

Wuttke, D.A., Rosenzweig, E.D., Heese, H.S., 2019. An empirical analysis of supply chain finance adoption. J. Oper. Manag. 65, 242–261.

Xu, L., Lin, C.T., 2007. Can Chinese banks compete after accession to WTO? J. Asian Econ. 18, 883–903.

Xu, L., Lee, S.C., Fu, Y., 2015. Impacts of capital regulation and market discipline on capital ratio selection: evidence from China. Int. J. Manag. Financ. 11, 270–284.

Xu, L., McIver, R., Shan, G., Wang, X., 2016. Governance and performance in China’s real estate sector. Manag. Financ. 42, 585–603.